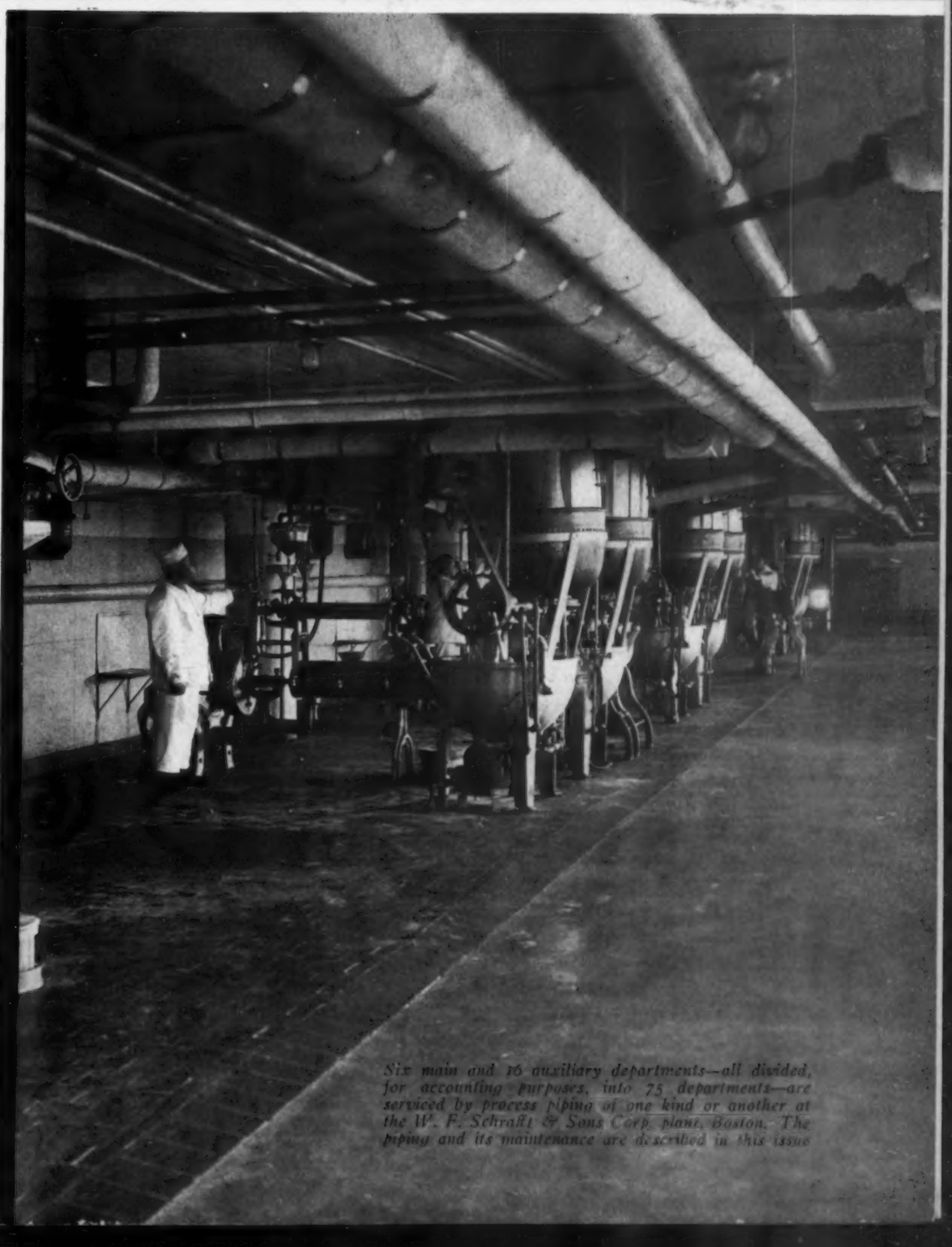
Heating · Piping and Air Conditioning



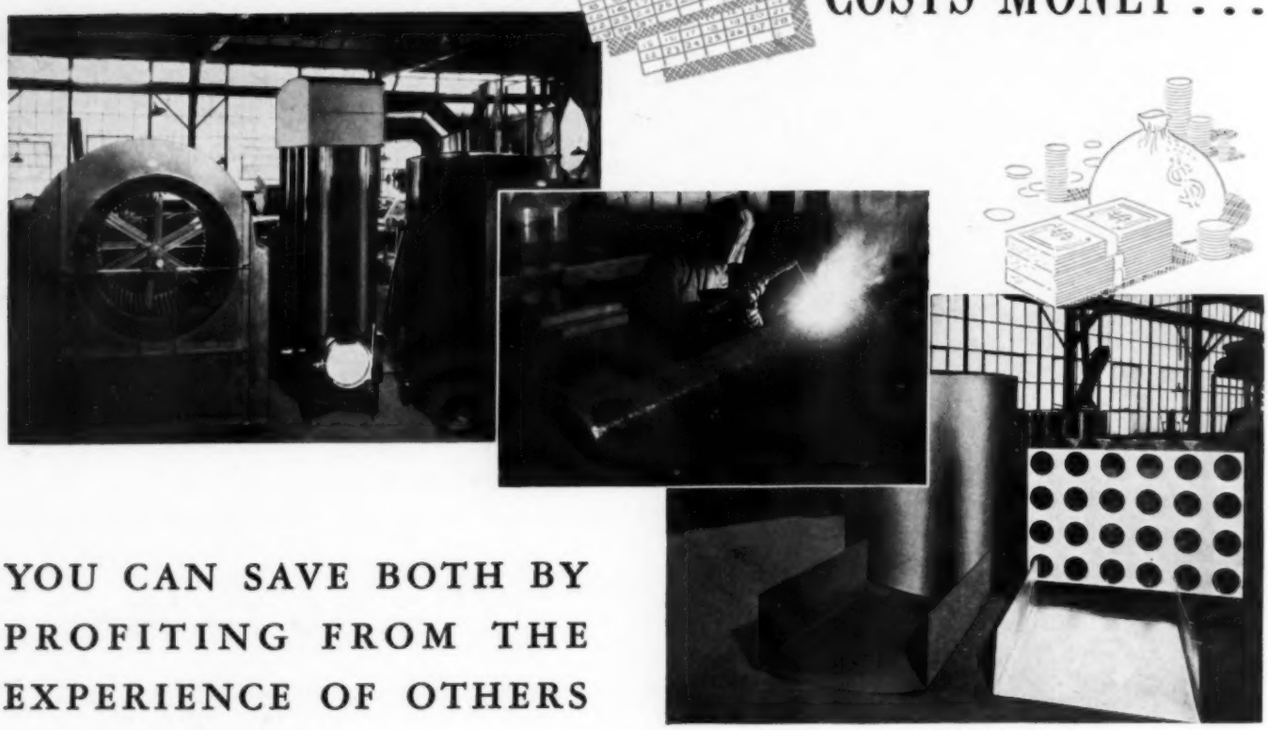
Six main and 16 auxiliary departments—all divided, for accounting purposes, into 75 departments—are serviced by process piping of one kind or another at the W. F. Schrafft & Sons Corp. plant, Boston. The piping and its maintenance are described in this issue

Heating · Piping
and Air Conditioning

EXPERIMENTATION

TAKES TIME

COSTS MONEY . . .



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■ **Largest single contract** for refrigerating and water cooling equipment for air conditioning ever let was the contract awarded for the 4800 ton central station type air conditioning system to be installed in the new Capitol Power Plant building in Washington, D. C., according to S. E. Lauer of York Ice Machinery Corp., the low bidder. Amount of the bid was $603,775. . . . The Air Conditioning Bureau of Boston, Mass., marked the opening of the first completely air conditioned hospital in the world—the Corey Hill Hospital, Brookline, Mass.—November 27. . . . Installation of air conditioning in the Dominion Public Building, Canada's first air conditioned public building in Hamilton, Ontario, may presage an extensive program of government air conditioning in Canada, such as our own government has conducted in Washington, D. C., according to York Ice Machinery Corp., whose equipment is used.

■ **Twenty-fifth anniversary** of air conditioning is being marked by Carrier Corp. this month, for on December 8, 1911, Willis H. Carrier presented his paper on rational psychrometric formulae before the American Society of Mechanical Engineers. Mr. Carrier offered four principles underlying the theory of the evaporative method of moisture determination, as well as air conditioning, and included experimental demonstrations of these fundamentals. . . . At the same meeting, Mr. Carrier presented a second paper on air conditioning apparatus.

■ **New president** of the Refrigerating Machinery Association is J. M. Fernald, general manager of Baker Ice Machine Co., Inc.; A. H. Baer, vice-president of Carbondale Machine Corp., was elected first vice-president of the association at its annual meeting in Washington last month. D. Norris Benedict, vice-president and general manager, Frick Co., Inc.; G. A. Heuser, secretary-treasurer, Henry Vogt Machine Co.; J. I. Lyle, president, Carrier Corp.; W. S. Shipley, president, York Ice Machinery Corp.; and Emil Vilter, chairman of the board, Vilter Mfg. Co., were named to serve with Mr. Fernald and Mr. Baer as the executive committee. . . . The International Acetylene Association, at its annual convention at St. Louis last month, awarded the Morehead medal for the year 1935 to Dr. D. S. Jacobus for his outstanding leadership in the formulation of codes and procedures which have made fusion welding acceptable. The medal is awarded annually by the association to the person or persons who have done most to advance the industry or the art of producing or utilizing calcium carbide or its derivatives. . . . The Engineering Institute of Canada is planning for the celebration of its fiftieth birthday in June, 1937. . . . Trustees of the Carnegie Corp. of New York granted $16,000 toward the support of the program of the Engineer's Council for Professional Development last month. Carnegie interest in engineering activities began in 1903 with a donation of $1,050,000 by Mr. Carnegie for erection of the Engineering Societies building in New York City. . . . To clarify its position as a non-profit service corporation, Underwriters' Laboratories, Chicago, has been reorganized without capital stock. The National Board of Fire Underwriters, which contributed to the original cost of the enterprise and under the direction of which it was established and has been maintained, continues its sponsorship.

■ **A four year survey** revealed a 34 per cent reduction in employee illness, according to a recent issue of the air conditioning news bulletin issued by Philadelphia Electric Co., 1000 Chestnut St., Philadelphia, reporting results of an analysis of two completely air conditioned district offices and five district offices without air conditioning of the company. . . . The bulletin also summarizes the benefits of complete air conditioning of the Philadelphia plant of the American Tobacco Co. Lost time was reduced from 50 girls/day out for ½ day to 5 girls/day out for ½ day, labor turnover reduced by 100 girls during summer months, rejects reduced from 3 per cent to 1 per cent, and production increased from 3600 cigars per machine per day to 4000 cigars.

■ **A new plant** devoted exclusively to manufacture of "V" type air filters for air conditioning and ventilating units has been opened in Chicago by American Radiator Co. A research and development laboratory is also being equipped. . . . Construction of a modern research laboratory to replace the research building leveled by an explosion last December was announced last month by the American Rolling Mill Co., Middletown, Ohio. The building will be of porcelain enamel sheets and other decorative metal products, and glass blocks. Six products of the company and its subsidiaries are being used as principal construction materials. . . . Automatic Products Co., Milwaukee, Wis., moved to new and larger quarters last month, with something over 60,000 sq ft of manufacturing space. One of the advantages of the new building is that all production will be on one floor. . . . The new Chrysler international automobile salon in the Chrysler building, New York City, is equipped with America's largest automobile show room air conditioning system, according to Airtemp, Inc., Chrysler subsidiary, whose equipment is used. Four separate conditioning systems totalling 80 tons of refrigeration are installed. . . . The salon has many unique features, including windows of "invisible glass" and a revolving circular show room floor for the display of cars.

■ **Stoker sales** for any one month broke all existing records in September of this year, according to the Committee of Ten—Coal and Heating Industries, based on statistics of the census bureau of the department of commerce. One hundred and eight manufacturers sold 16,612 units, an increase of 67½ per cent over the corresponding month for 1935. Stoker sales for the first nine months of this year represent a 79 per cent increase over the corresponding period of the previous year. . . . Twentieth anniversary of the American Society for Testing Materials' atmospheric corrosion tests on black iron and steel sheets was celebrated at a banquet at Annapolis, Md., October 16. The sheets were exposed at Annapolis on October 17, 1916, and since being put on the test racks have been inspected twice a year by a subcommittee of the A. S. T. M.'s committee on corrosion of iron and steel.

■ **Hardly a meeting** is complete these days without at least one paper on air conditioning. At the recent Midwest-Northern Conference of Building Owners and Managers, St. Paul, Paul E. Holcombe, Carrier Corp., discussed the present and future of air conditioning in office buildings. He pointed out that, while air conditioning is not a "deep and dark mystery," it does require engineering and experience, both in design and installation. The first office building having all the offices supplied with conditioned air was the Patterson Building, Fresno, Calif., conditioned in 1926, according to Mr. Holcombe. . . . Samuel R. Lewis, consulting engineer, described fundamentals of air conditioning to the National Association of Practical Refrigerating Engineers at the annual meeting in Chicago

(*Continued on page* 119, *back section*)

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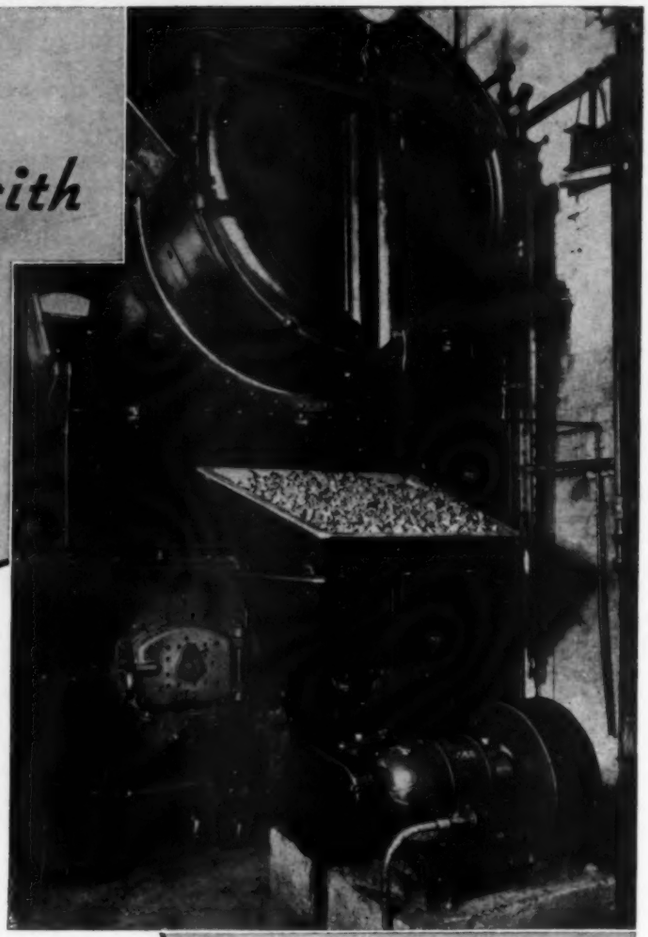

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From the above you can readily see that we are highly pleased with our Stoker and we are positive that the saving in labor and coal will pay for the Stoker in one year.

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B. E. Jordan, Treas.

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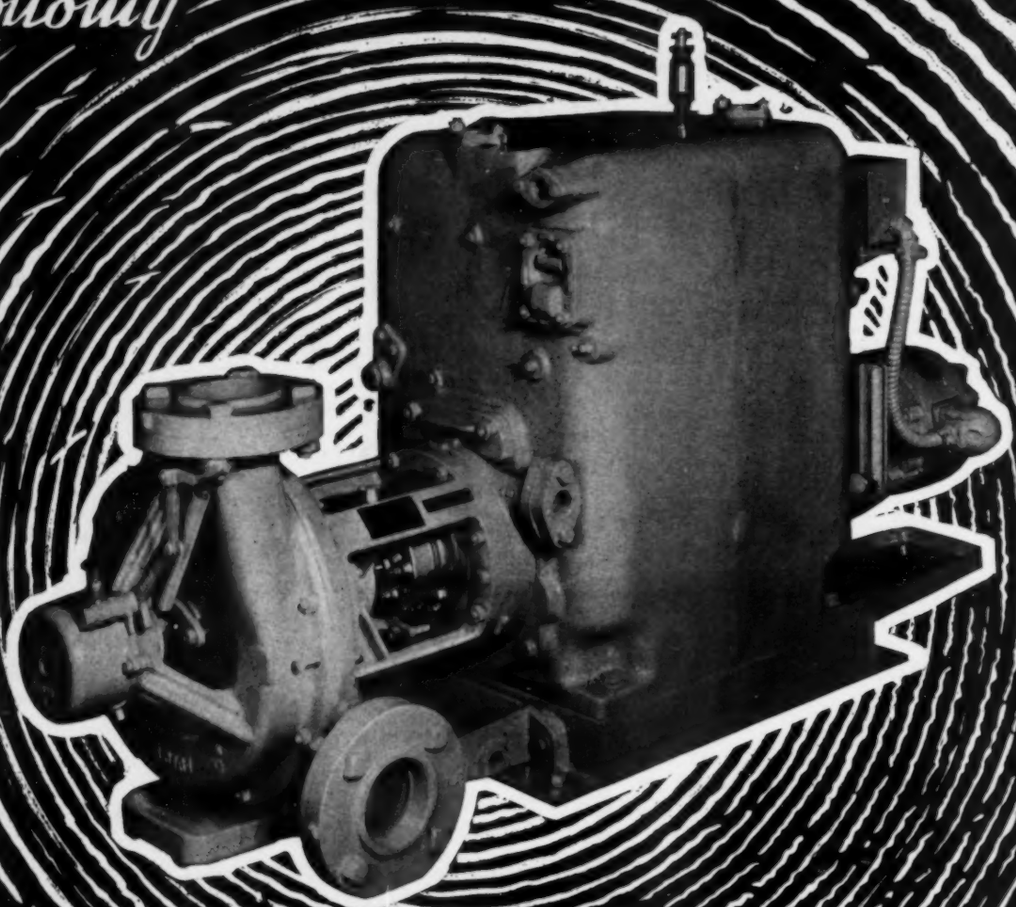
Centralized Heating Economy



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Heating · Piping and Air Conditioning

Vol. 8, No. 12 • *December, 1936*

Fusion Welded Power Piping

Standards for Quality of Welding and Methods of Inspection

By Wm. D. Halsey*

THE company which I represent insures boilers, unfired pressure vessels, pipe lines, engines, turbines and electrical machinery against the damage resulting from certain kinds of failures as described in the policy of insurance. We make periodic inspections of the equipment which we insure to determine whether such equipment is in safe operating condition. We are also extensively engaged in making shop inspections of boilers and pressure vessels constructed under the requirements of the *A. S. M. E.* code. As a natural outgrowth of this shop inspection service we have been extensively engaged in the inspection of fusion welded pipe lines during construction.

As an insurance company making inspection of fusion welded pipe lines we are interested primarily in safety, and it will be apparent that the safety of a fusion welded pipe line resolves itself almost wholly into a question of the physical properties of the fusion welded joints.

Quality of Welding for High Pressure Piping

Considerable thought has been given to the quality of welding which should be required in high pressure pipe line work. Many purchasers, having in mind the classification for fusion welded pressure vessels adopted by the *A. S. M. E.* code, have specified "Class 1" for the quality of the welding. The intent of the code in referring to classes was primarily for a distinction in the degree of severity of service for a vessel rather than for the quality of the welding, although there was some difference in the requirements for weld quality. Because of the improper interpretation placed upon the designations "Class 1," "Class 2," and "Class 3," the unfired pressure vessel code has discontinued these designations and now refers to paragraph designations such as "U-68," "U-69," and "U-70." There is little difference in the tensile strength, ductility, and soundness requirements of welds for U-68 (formerly Class 1), and U-69 (formerly Class 2) pressure vessels. The outstanding difference between the two lies in the manner of accomplishing the end desired. For U-68 vessels a test weld must be made for every vessel, the major seams must be radiographically examined, such as by X-ray, and all vessels must be stress relieved by heating. For U-69 vessels, the intent is that a procedure for welding must be adopted by the manufacturer, which procedure must be investigated by making sample welds and testing such welds for tensile strength, ductility, and soundness. Every welding operator must then be examined for his ability to make welds—by the procedure that has been adopted—which will have the required tensile strength, ductility and soundness. It is assumed that if the adopted procedure of welding is followed and only qualified welding operators are used, that the results obtained in actual construction will conform to the results obtained under test.

The vast majority of vessels constructed under the requirements for fusion welded power boiler drums or for U-68 vessels are of such a size that they may be entered for the placing of the X-ray film. In this connection it must be borne in mind that to obtain the best results in X-ray examination the film must be placed close to the weld being examined and on the side opposite the X-ray tube. Furthermore, that the majority of boiler drums and unfired pressure vessels have longitudinal seams in which the imposed stress from the working pressure is twice that which is imposed on a circumferential seam.

Fusion welded power boiler drums and U-68 pressure vessels must be stress relieved either by heating the complete vessel as a unit or by heating complete sections of the vessel.

In a fusion welded pipe line to meet completely the requirements of the *A. S. M. E.* code for "Class 1," or what is now known as "U-68," it would be necessary that every welded joint be examined by X-ray. It will be apparent that such a procedure would be impractical and in most cases, impossible.

*Assistant Chief Engineer, Boiler Division, The Hartford Steam Boiler Inspection and Insurance Co., Hartford, Conn.

To meet the stress relieving requirements every two sections of pipe that are connected would have to be placed in a stress relieving furnace after the welded joint between the two sections had been completed. For every group of welded joints it would be necessary that a test weld be made for determination of tensile strength, ductility, and specific gravity.

When consideration is given to all the requirements of the *A. S. M. E.* code for fusion welded power boilers and U-68 vessels, it will be apparent that they cannot be met, from a practical standpoint, nor are they applicable to fusion welded pipe line construction. The proper procedure for fusion welded pipe lines is to call for a specified technique of welding, an investigation of that technique of welding to determine that it will produce certain desired results, qualification of the welding operators under such procedure of welding, and an insistence that the procedure of welding be followed in actual construction. It is upon this principle that the requirements for welding in the *A. S. A.* code for pressure piping are based, although certain recent developments have brought about some changes with respect to the method of qualifying welding operators, which the writer believes might well be incorporated in the *A. S. A.* code.

Inspection Procedure for Pipe Lines

Within the near future our company will adopt a new inspection procedure for pipe lines we are called upon to inspect. Our first requirement will be, as heretofore, that the fabricator or piping contractor adopt a specific procedure for welding and that he demonstrate to our representative that such procedure will produce welds having satisfactory tensile strength, ductility and soundness. The method to be followed to determine these facts is outlined in the "Tentative Rules for the Qualification of Welding Processes and Testing of Welding Operators" as published by the *American Welding Society,* 33 W. 39th St., New York, N. Y.

Our second requirement will be for the fabricator or contractor to demonstrate to our representative that all welding operators can make sound welds when they follow the procedure of welding outlined and which has been investigated and found satisfactory. The procedure for the qualification of a welding operator is outlined also in the tentative rules referred to.

The third requirement will be that a representative of our company make some visits of inspection during the fabrication of the pipe line for the purpose of determining that the procedure for welding is being followed. Particular attention is paid to the materials that are being used, as such materials determine to a large degree the quality of weld metal that will be obtained.

It will be required that all welding operators be assigned an identifying number or symbol and this number or symbol must be stamped adjacent to every weld which the operator makes. Upon the completion of the work the inspector will remove from the pipe line a complete welded joint, or a specimen from a joint for each welding operator, and these welds or specimens will be examined for soundness.

So long as such examinations show that the individual operator is doing acceptable work by that process of welding, no requalification tests will be required. In other words, the individual operator must pass an initial examination to demonstrate his ability, and will be held fairly close to that quality of workmanship through the medium of a check on his work on the job. In some special cases some other method of inspection may be agreed upon by the owner or purchaser and the inspecting company.

The final step in the inspection will be, of course, the hydrostatic test.

Some points of the above procedure in the inspection of fusion welding on pipe lines are worthy of further discussion.

It is of particular interest to note that the *American Welding Society's* tentative rules recognize the principle that tensile strength and ductility in weld metal are determined by the procedure or technique of welding followed. This procedure or technique involves all the variables encountered. Consideration is given not alone to the question of whether the gas or metallic arc process is used, but also to the specific kind of welding wire used, to the shape of the welding groove, to the quality of flame used, to the number of beads deposited, and several other items. When it has been determined that a given procedure for welding will produce certain tensile strength and ductility of weld metal, it is then a useless procedure to test every welding operator for tensile strength and ductility because those qualities are predictable under the given procedure. For the qualification of a welding operator under any given process we desire to know not whether he can produce welds of a certain tensile strength and ductility, but rather whether he can make a *sound* weld by that process. By a sound weld we mean one that is properly fused and without excessive slag inclusions or porosity.

The tentative rules for the qualification of welding processes and testing of welding operators give suggested forms for the writing of specifications for different methods of welding but I shall not attempt to discuss these suggested specifications, except to state that no specific instructions for welding are given. It is the duty of the person or persons having responsible charge of the welding to write the specifications setting forth in detail the method to be followed. No limitations are placed on the methods to be used and there is entire freedom for the development of new ideas.

Test Specimens and Qualification of Welders

For the qualification of a process, it is necessary that welded pipe joints be made in those positions which are to be encountered in actual construction, and the welding of these joints must be done in accordance with the specifications. From each of these joints there are removed two reduced section tensile specimens, two free bend specimens for ductility, two root break specimens, two side break specimens, and two nick break specimens. The methods of preparing these specimens for testing are shown in the tentative rules published by the *A.W.S.*

The methods for testing the tensile, free bend, and nick break specimens have been in general use for several years and need no comment now. In the case of pipe lines which are welded with backing strips or chill rings on the inside of the pipe, the specimens are polished on the sides and etched in a boiling solution of 50 per cent hydrochloric acid and water. This method of testing is used instead of the root break to determine what penetration into the chill ring has been obtained.

The side break test is somewhat new and some re-

A thorough review of standards for quality of welding and methods of inspecting fusion welded high pressure piping is given in this article, which is taken from a paper read at the annual convention of the *International Acetylene Association* at St. Louis last month . . . The differences between the welding and inspection of piping and pressure vessels are pointed out, the new inspection procedure to be adopted by The Hartford Steam Boiler Inspection and Insurance Co. is described in detail, and test specimens and the qualification of welders are discussed

Fig. 1 (*top*)—The nick break specimens broke directly through from notch to notch . . . Fig. 2 (*center*)—The side break specimens broke through the side wall defect . . . Fig. 3 (*bottom*)—Several instances are known of where lines have been constructed by operators who had demonstrated their ability to make sound welds, yet joints have been cut from the line and unsound welds found. This is an example

search work done in connection therewith may be of interest. It had been felt that the nick break specimen might not reveal defects that might exist on the side walls of the welding groove. To investigate this matter a defective weld was made in which there was a slag streak of somewhat minor proportions on the side wall. The weld was X-rayed and it was found that the defect continued throughout the length of the weld. Four nick break specimens were removed and three side break specimens. Two of the nick break specimens were broken in the customary manner with a quick, sharp blow, and the other two nick break specimens were broken by a slow bending. All of the nick break specimens broke directly through from notch to notch, Fig. 1. The side break specimens broke through the side wall defect, Fig. 2.

In the qualification test for welding operators only the face break, root break, side break, and nick break specimens are used. The face break test is made in the same manner as the free bend test except that no measurement is made of ductility.

It is not to be expected that perfect welds will be demanded. There must be some tolerance and, therefore, there must be some method of evaluating lack of soundness. For this, consideration must be given to what constitutes a defect. The rules define defects as follows:

Defects are defined as gas pockets, slag inclusions, and lack of fusion exceeding ——— in. in greatest dimension.

The rules have not attempted to give any definite limit on the size of a defect as it has been felt that these values should be left to the discretion of those who adopt the rules.

The rules evaluate lack of soundness in the following manner:

Lack of soundness shall be evaluated by the total depth of all "zones of defects," measurement being made of such depths on a line or plane parallel to the throat of the weld. A "zone of defect" is defined as the area within two lines perpendicular to the throat of the weld and bounding any one defect or any group of defects whose depths are overlapping.

The rules give illustrations of typical cases of "zones of defects."

The rules also contain the following statement:

The permissible total depths of all zones of defects on any plane parallel to the throat of the weld shall not exceed ——— per cent of the specified weld throat dimension in the case of fillet welds or of the center of the two parts joined in the case of butt welds.

The length of any permissible defect shall not exceed——— times the plate thickness nor shall any two defects be closer together than ——— times the plate thickness.

The rules have again left blank the values to be inserted by those adopting the rules.

Our company has adopted the following standards for welded joints in pipe lines:

Test Results

Tensile Test—The reduced section tensile test specimen shall show an ultimate tensile strength not less than 90 per cent of the tensile strength of the pipe material.

Free Bend Test—The ductility by the free bend method shall be not less than 20 per cent.

Soundness—The permissible total depth of all zones of defects on any plane parallel to the throat of the weld shall not exceed 10 per cent of the specified weld throat dimension in the case of fillet welds, or of the thinner of the two parts joined in the case of butt welds.

The length of any permissible defect, measured on a line perpendicular to the throat of the weld, shall not exceed ½ in.

Defects are defined as gas pockets, slag inclusions, and lack of fusion exceeding 1/16 in. in greatest dimension. For single welded butt joints without backing rings, all defects in a zone of 10 per cent of the pipe wall thickness at the root of the weld may be disregarded.

When joints or specimens of joints are removed from the completed line for examination, no single zone of defect in excess of 10 per cent nor a total of all zones in excess of 20 per cent of the pipe wall thickness will be permitted. The 10 per cent zone at the root of the weld in single welded joints without backing up strips will be disregarded and the ¼ in. limitation on the length of a defect will not apply to lack of fusion between layers of welding.

If the defects found exceed 50 per cent of the wall thickness the work of that welding operator will not be accepted. If the defects exceed the 20 per cent limit given above but not the 50 per cent limit, two additional joints or specimens for each welding operator will be removed. Should these additional joints meet the 20 per cent requirement the work of that welding operator will be accepted. However, if either one of the additional joints or specimens shows defects exceeding the 20 per cent limit, the work of that welding operator will not be accepted.

When a complete joint is removed from the line, examination will be made by a root bend test of specimens taken at the top, bottom and two sides of the joint and all specimens must meet the requirements. If they do not, the remainder of the joint may be subjected to the root bend test and judgment of the joint made upon the average condition of all specimens.

It must be understood, however, that even though the specimens may technically meet the requirements, the inspector shall have the right to call for additional specimens if in his judgment further investigation is necessary to determine satisfactorily that the welding is safe.

The matter of position in which the welding is done is of paramount importance and a procedure of welding should be investigated not in one position but in all positions which may be encountered in actual construction, and an individual welding operator should be examined for his ability in all positions. Furthermore, it must be borne in mind that the average welding qualification test is made under the most advantageous conditions and surroundings. Frequently the welding operator must encounter much more difficult conditions and more unpleasant surroundings on the actual job.

I appeal to those of you who have responsible charge of welding to give serious thought to these matters and determine to your own positive satisfaction, and not by the word of any other person, that a certain technique of welding which you may decide upon is proper and that you insist that such technique be followed in executing work for which you are responsible.

As regards the requirement that a welded joint or sample from a welded joint be cut from the work of every welding operator, I want to bring to your attention some very pertinent facts. A welding operator may demonstrate his ability to make a sound weld by a given process and under the most adverse conditions. Human beings are at times, however, peculiar individuals in that, while they may have the ability to do a certain job, they do not always extend themselves to accomplish the results of which they are capable. We know of several instances of welded pipe lines that have been constructed by operators who had demonstrated their ability to make sound welds, yet joints have been cut from the line and unsound welds have been found, Fig. 3. A constant prodding thought in the mind of the operator to encourage him to do his best work at all times will have a most beneficial effect and will, I am certain, be the most effective instrument that can be used to secure properly welded joints. Certainly no competent and conscientious welding operator could possibly object to such a procedure. Both employer and employee, knowing that a sample of the actual work will be examined, but not knowing just where the sample will be taken, are stimulated to continuously endeavor to avoid the penalties attached to unacceptable work.

I have appealed to those of you who have welding in charge to interest yourselves in the fundamental requirements of welding and the procedure that should be followed to obtain welded joints of proper quality. In this connection I am fearful that at times the welding operator has been asked to undertake work that is, in general, rather difficult of accomplishment. Whereas, under test, acceptable results may be obtained, the procedure adopted is so difficult that only by the most rigid attention to his work may the operator obtain a soundly welded joint. I have in mind in particular the question of the amount of molten metal that a welding operator is asked to control and which our experience has shown may often interfere seriously with his doing good work.

When the oxy-acetylene process is used, I recommend for your earnest consideration the adoption of multiple layer welding on pipe lines and in connection therewith I call attention to the papers presented on the subject at the recent meeting of the *American Welding Society*.[1]

[1]See HEATING, PIPING AND AIR CONDITIONING, November, 1936, pp. 613-617; December, 1936, pp. 677-678.

A. C. Benefits Candy Maker Three Ways

Three-fold are the benefits of air conditioning to the Flavour Candy Co., Chicago. Functions of the air conditioning system are (1) to harden chocolates rapidly

Photo courtesy York Ice Machinery Corp

in a candy tunnel 30 ft long, (2) to preserve the shape and appearance of candies in the dipping and storage room into which the tunnel discharges cool air, and (3) to keep the employees comfortable.

The "Freon 12" conditioning system supplies 2500 cfm of air. Windows are double glass, and both tunnel and workroom are insulated.

The installation was made by Westerlin & Campbell.

How Much Noise Is Permissible?

P. H. Geiger* discusses the amount of noise it is permissible for air conditioning equipment to make, includes practical suggestions for reducing noise. An important subject, as architects' specifications calling for noise levels below a certain value are becoming more and more common

INSTRUCTIONS for computing the loudness of the noise made by air flowing through a grille of any size and in any room were given in a previous issue.[1] This month the amount of noise which is permissible in various locations is considered. Suggestions for making quiet air conditioning installations or quieting them after they are installed are included.

Permissible Grille Velocities

If the noise made by an installation is kept so low that it does not noticeably increase the noise level already existing in the room, all concerned will be satisfied. On first thought it might seem rather difficult to comply with this condition, but actually it is not, for the ear has the characteristic of hearing the loudest sounds present and neglecting sounds only slightly quieter. In other words, the noise already in a room will mask out the noise made by a machine or other equipment if the loudness level of the equipment is only six or seven decibels less than that of the existing sound.

The increase in loudness level of a room due to the addition of grille noise (or any other noise) is shown by Fig. 1. Suppose, for example, that a grille is to be installed in a room where the loudness level is 40 db (decibels) and suppose that an air velocity has been chosen that will give a noise level of 35 db. To find the loudness level in the room after the installation it is only necessary to follow up the vertical line corresponding to 35 db on the horizontal axis, to where it meets the curve corresponding to a room noise of 40. The value of room noise with grille noise present is given as 41.6 db on the vertical scale. Thus it is evident that the addition of a 35 db noise to a 40 db noise increases the latter by only 1.6 db. Fig. 2 shows that a change of 1.6 db at this loudness level is so small that it can be detected only by careful observation.

[1] "How to Avoid Trouble from Noise in Air Conditioning Installations," HEATING, PIPING AND AIR CONDITIONING, November, 1936, pp. 601-604.

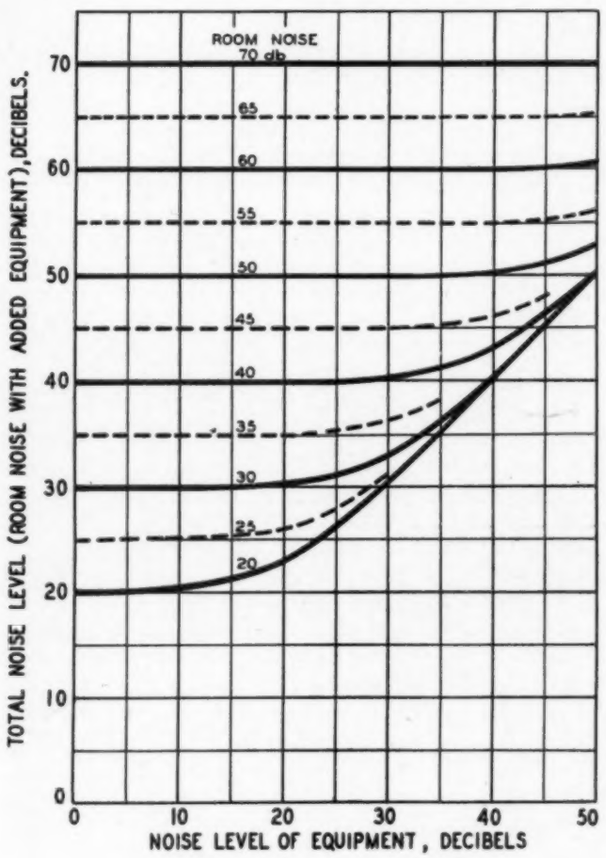


Fig. 1—How room noise is increased by equipment having a known noise level

There are some important exceptions to the rule that the addition of a noise 5 or 10 db below the original noise will not perceptibly increase it. It is true that an increase in loudness of about 1 db (at the loudness levels under consideration) is not noticeable, but if the increase in loudness is brought about by the addition of a distinctive sound, such as the tone produced by a fan, the change in the character of the sound can be perceived even though there is not a perceptible increase in loudness. For this reason, if the blower possesses a distinct fan tone it will be necessary to adopt means of reducing the blower noise to a value 15 or 20 db below the original noise level in the room.

Thus, it is seen why the impression is often held that there is a definite velocity at which grille noise becomes objectionable. If the velocity is slowly increased as a person listens, there will appear to be a fairly definite velocity at which the noise becomes audible. However, if the experiment is repeated in another room—or perhaps in the same room at another time—a quite different velocity may be decided upon as being objectionable. The reason for this is that the velocity determined by this experiment will be greatly influenced by the noise level already existing in the room because the noise cannot be heard so long as the velocity is such that the noise is less than about 5 db below the room noise. However, as the velocity is increased only slightly above this value the noise will become easily noticeable.

If an installation is to be designed for a room the noise level of which is known, or if a noise specification is supplied by the architect, the computations can be made as described in the November article.[1] However, the contractor usually does not have this information. He will, therefore welcome assurance that the installation will be satisfactory without being compelled to

*Research Physicist, Department of Engineering Research, University of Michigan, Ann Arbor, Mich.

reduce the air velocities to values unnecessarily low. Table 1 has been prepared for use in such cases. In this table are given the velocities for several sizes of grilles for various types of rooms, which, in the writer's opinion, will be satisfactory in almost every case.

Since the noise level of any room is by no means a definite, fixed quantity and since the noise levels of rooms used for the same purpose will vary from locality to locality, it is impossible to set definite figures. The figures given are conservative and should prove satisfactory in almost every instance. However, the contractor may size up the job and make corrections to fit. For example, if an air conditioning unit is to be set up in a bedroom in a quiet suburban district and the owner makes inquiries about the noise the apparatus makes, it will probably be wise to use a velocity 25 or 30 per cent less than that given in Table 1. On the other hand, if the bedroom is situated in a noisy apartment house next to an elevated train line and if the occupant appears to be leading a calm and placid existence, the table can be forgotten and as much air blown through the grille as is possible.

The table has been computed for two grilles whose noise curves were given in a figure published with the previous article.[1] Grille *A* is a noisy grille having a wide air spread and Grille *B* a quiet grille with a narrow spread. If the manufacturer can not furnish a noise curve for the particular grille to be used, it will be safe to use the figures for Grille *A* if the spread is wide and figures halfway between Grille *A* and Grille *B* if the spread is narrow.

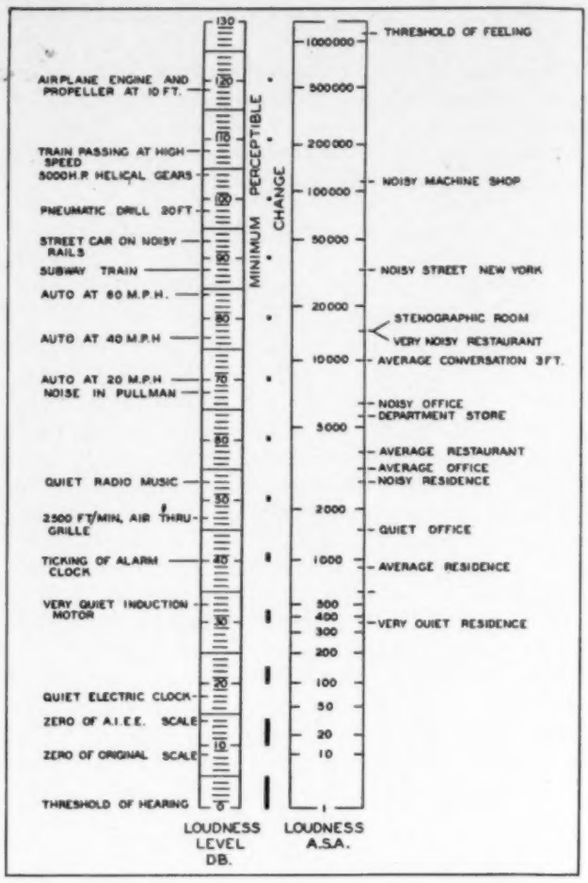


Fig. 2—Comparison of loudness level and loudness scales. The short line segments in the center show the smallest change in loudness which can be perceived

Methods of Reducing Noise

Since this paper is written for the installer of air conditioning equipment rather than the equipment manufacturer, suggestions for quieting are confined to procedures to be used in the installation of the equipment.

To keep grille noise down to the desired value, the answer is obviously the use of low velocities. However, if the installation demands a long throw, the installer has no choice but to use a sufficiently high velocity. If it is found that the conditions of the installation require a higher velocity than that given by Table 1, earnest consideration should be given to the plans to see if they cannot be altered so that shorter throws may be used. It may be that an increase in the number of grilles distributed throughout the room will permit the use of low velocities.

The value of flexible mountings for quieting motors is well known, yet frequently they are used so that little if any quieting is secured. The object of such mountings is to prevent the transmission of vibrations from the machine to any large surface, such as a wall. If a bolt touches both the motor and the supporting frame, most, if not all, of the advantage of the flexible mounting is lost. Bolts insulated with soft rubber provide the remedy, or the mounting can be arranged so that no bolt touches both the supporting structure and the motor. A test of the efficacy of the mounting may be had by comparing the noise made by the motor when mounted and when held in the hands. If the mounting increases the noise noticeably, it is not as effective as it might be.

Table 1—Permissible Velocities Through Grilles of Various Sizes
(Feet per Minute)

Room	Permissible Noise Level (Decibels)	Grille *A*				Grille *B*			
		0.5 sq ft	1 sq ft	2 sq ft	4 sq ft	0.5 sq ft	1 sq ft	2 sq ft	4 sq ft
Residence, living room	35	800	700	625	550	1600	1450	1350	1250
Residence, bed room	25	500	450	400	350	1200	1100	1000	900
Office, quiet	40	950	850	750	700	1900	1700	1550	1400
Office, average	50	1450	1300	1125	1000	2700	2400	2100	1950
Restaurant, quiet	45	1150	1050	925	675	2200	2000	1800	1625
School room	50	1450	1300	1125	1000	2700	2400	2100	1950
Church	45	1150	1050	925	675	2200	2000	1800	1625
Theater	45	1150	1050	925	675	2200	2000	1800	1625
Theater, motion picture	55	1800	1600	1400	1200	2900	2700	2500	2300
Store, quiet	45	1150	1050	925	675	2200	2000	1800	1625
Hospitals	40	950	850	750	700	1900	1700	1550	1400
Broadcasting studio	15	350	300	250	200	850	750	650	500

Areas given are nominal areas (duct size) as given by the manufacturer; they are not the free areas.

To determine whether an unwanted noise is due to the motor or the blower, turn off the power and listen. Motor noise, other than that due to poor bearings, will die out immediately, whereas the blower noise will continue for a short time. Sometimes a decrease in noise may be secured by setting the blower on soft cork or rubber and by using short sections of canvas ducts.

If the blower noise is loud enough to be carried through the ducts to the occupied rooms, lining the ducts with a sound absorbing material will result in a marked improvement, especially if the lining is continued around a bend in the duct. In lining ducts it should be remembered that noise can travel up the return air ducts as well as it can the supply ducts, so both should be lined for an equal distance. Except in extreme cases it is unnecessary to line more than about 10 ft. Effectiveness of a duct lining is increased if it is carried around a bend in the duct. The most effective place for sound absorbing material is the place where the sound is the loudest, which usually means near the blower. If the blower is in a small room, with no sound absorbing surfaces, some improvement, especially for high pitched sounds, may be had by covering part or all of the wall and ceiling surfaces with sound absorbing material.

Use of Sewage Water as Condensing Medium for Air Conditioning Plants Has Possibilities

By E. P. Heckel*

A REFRIGERATING machine is in reality but a heat pump, lifting heat from one level to a relatively higher one. The effluent heat must be carried away by some means, usually condensing water. Either fresh water from city mains or water pumped from wells may be used, or cooling towers, spray ponds, or evaporative condensers may be employed. With an evaporative condenser the effluent heat is carried away by the air blown over the wetted condenser coil surfaces.

So far as the writer knows, the idea of utilizing sewage water has never been employed in actual practice. It seems to present, however, some reasonable possibilities, especially where the questions of procuring and disposing of sufficient condensing water are involved. With this in mind an investigation was made in connection with the design of a certain air conditioning plant to determine some facts regarding sewage water conditions and volumes available.

It was found that the temperature of the sewage water was very close to the temperature of water available from the city mains. It was also found that the sewage water in the sewage mains approximates 80 per cent liquid and 20 per cent solids by volume, and that this sewage water could by a simple process of screening be made usable in the quantities necessary. The water could be taken from the sewer at one point, circulated through the condensers, and returned to the sewer at a reasonable distance from the point of suction and at a lower elevation. It was estimated that the cost of screening and skimming, to remove the surface accumulation of grease, would be reasonable. It was considered essential that a high velocity should be maintained through the condenser coils to prevent settling of suspended solids.

In analyzing the question of acidity we were informed by a chemical engineer that in almost every case tested sewage has a slightly alkaline reaction and thus would not destroy the metals used for condenser tubes. We learned further—from a very reputable firm of civil engineers—that the heat imparted to the sewage water would be beneficial rather than detrimental. It therefore seems reasonable to believe that sewage fluid can be utilized in this way under favorable circumstances; it must, of course, be understood that the number of such connections to the sewers would be limited in a given area.

The result of this study was rather interesting, but upon final consideration the scheme was rejected on one count only—and that was for psychological reasons. It was felt the public might think that air conditioning was accomplished by the use of sewage water, and without realizing just how the sewage water was utilized would form an unfavorable opinion.

*Carrier Corp., Chicago, Ill. Member of Board of Consulting and Contributing Editors.

Standards for A. C. Noise Control

The section on noise control of the revised edition of the Chicago standards for comfort air conditioning, dated October, 1936, provides that:

"No noise resulting from the operation of an air conditioning system shall exceed the loudness level of the noise in the room when the normal activities in the occupied space are in progress and no part of the air conditioning system is operating. The loudness level of both the noise in the room and noise produced by the air conditioning system shall be expressed in decibels and measured with a sound level meter constructed according to American Tentative Standards for Sound Level Meters Z24.3—1936. Noise measurements shall be made at a height of five feet from the floor of the space to be air conditioned and no reading shall be taken closer than five feet from any wall, register face, window, or ventilation equipment."

The revised supplement to the standards of the same date states that: "To determine the normal noise level in the room, measurements shall be made in not less than ten different locations uniformly distributed on the plane and within the boundaries specified by these standards. The numerical average of these measurements shall be taken as the normal noise level of the room."

Piping Plays Important Part at Schrafft's

Cream boiling and beating department, showing syrup coolers overhead and syrup boiling and cream remelting kettles in rear

By L. P. Leathers*, with Francis A. Westbrook

WHEN W. F. Schrafft & Sons Corp. built its present plant in the Charlestown district, Boston, for the manufacture of high grade candies, great care was given to the design, layout and installation of its equipment to insure the quality of its products and economical operation. Piping alone cost something like $300,000.

The process piping includes hot and cold water, steam at 6, 90 and 120 lb ga, and the returns. There are six main departments and 16 auxiliary departments, all divided—for accounting purposes—into 75 departments serviced by process piping of one kind or another, and in many cases by all of them. The returns are galvanized wrought iron, and the steam piping is black steel, which is less expensive and has proved satisfactory for the requirements.

The power piping includes steam piping in the power house, compressed air, fresh water, sea water, refrigerated water and brine. The steam piping is of black steel; that for compressed air, galvanized steel; for fresh hot water, brass; and for cold water, galvanized wrought iron. Cast iron is used for sea water because of its resistance to sea water corrosion, and the piping for the refrigerated water is black steel. Black steel is also used for the brine piping for cooling the finished goods storage rooms.

Chilled Water Piping for Air Conditioning

There is an interesting story about the experience with the refrigerated water piping which, from the maintenance standpoint, may be of value to others. As a preliminary it should be explained that air conditioning is employed in many departments to facilitate processing and packing of different kinds of candy. Most of the departments have similarly conditioned air, but in a few of them, such as the hard candy department, the moisture content is kept lower than in the others because of the moisture absorbing properties of the product. For all factory air conditioning there are three conditioning machines located at strategic points on the seventh floor and having a total of 5,000 spray nozzles. In the beginning a good deal

*Plant Engineer, W. F. Schrafft & Sons Corp., Boston, Mass.

of trouble was experienced with the nozzles, which was due to two causes.

The air returned from the building is laden with CO_2 and other gases. The water absorbs these gases and tends to become acid in reaction, especially as it has to be used over and over again in order not to waste refrigeration. This acid reaction was harmful because it eroded the steel piping leading to the washers and dislodged scale in it. It also eroded the nozzles and the dislodged scale plugged them. The acid also set up a reaction on the brass tubes in the interchangers on the refrigerating machines, causing pitting and frequent leaks due to puncturing. Consequently it is necessary to treat the water to keep it neutral. This is done by periodically injecting a neutralizing solution in the main water lines. The water is tested several times daily with a La Motte bloc comparator which gives the pH value, and enough of the solution is injected to keep this at about 8, or slightly on the alkaline side. Proper use of this testing equipment and of the neutralizing solution have practically done away with the trouble.

Realizing the importance of carefully designed and installed piping—and its proper maintenance—particular attention was given to the piping services when the Schrafft plant in the Charlestown district, Boston, was built . . . The functions of piping in the manufacture of high grade candies are described here, some of the things the Schrafft organization has learned about piping are explained, and practical information on piping maintenance is given

The second cause of trouble with the refrigerated water system was due to the fact that the continual flow of water at high velocity resulted in a loosening of scale from the wrought steel headers and rapid wear and clogging of the nozzles. The nozzles had to be inspected frequently and cleaned at least every three months, plus the day-to-day attention required to keep them operating properly. This difficulty was done away with by replacing the headers with brass pipe and now a yearly inspection is sufficient. These nozzles have holes about 0.095 in. in diameter and if they show an opening of 0.105 in. or more when tested with a plug gauge they are replaced. Replacements have been cut in half, and trouble from clogging has been practically eliminated.

Melted Chocolate, Corn Syrup Circulated

Melted chocolate and corn syrup are delivered to the points of utilization by means of circulating piping systems covering three floors. Thus the corn syrup system, for example, has a tank on the sixth mezzanine floor and a pump which maintains constant pressure on the line. There are branches from the main line to the points at which the raw material is used, and what is not used is returned through the loop to the tank. The arrangement for the chocolate piping is similar.

The chocolate piping is of black steel, which was washed with a caustic solution and pounded to remove all scale before being installed; 2 and 3 in. pipe is used for this service. Underneath, and in contact with it, is placed ½ or ¾ in. black steel pipe for 6 lb steam to keep the chocolate in a sufficiently fluid condition. The two pipes are wrapped together with three layers of sheet asbestos with an overall sewed-on canvas jacket which is painted. The corn syrup piping is similar to the chocolate piping, except that galvanized wrought iron pipe is used because the sugar tends to corrode black steel, which is not the case with chocolate.

Screwed Wrought Iron for Plumbing Lines

The plumbing offers some interesting features as it involves the use of a large amount of wrought iron pipe in an unusual way. In the old plant cast iron soil pipe was used, and trouble arose because many of the process returns going into the waste system are warm and others are alternately hot and cold. The consequent expansion and contraction of the hub and spigot soil piping kept the caulked joints working and moving, with the result that leaks developed at frequent intervals. It was also found that under the conditions existing, which involved the handling of waste with sugar, fats, etc., corrosion was such that the average life of the pipe was no more than 10 years. Taking care of the leaks was an appreciable item of expense, and in a plant where cleanliness is stressed as it is at Schrafft's, leaks are most objectionable.

Consequently this was a problem to receive careful attention when plans were made for the present building. It was for this reason that screwed wrought iron pipe, galvanized inside and out, was installed for all waste lines. The idea was that if this pipe lasted 10 years it would be a wise investment despite its higher first cost. So far it has been in service for eight years and the troubles which it was intended to avoid have not appeared except in small branch lines. Probably it has already been more than justified.

The severity of the conditions for the waste lines is shown by the fact that the small branch drains leading from individual machines and into which the wash-up water (which has a high sugar content) is discharged are so severely attacked that many of these drains have to be replaced every four or five years. As soon as a leak appears, usually at a threaded joint, it is taken care of at once by replacing the whole branch. This, however, does not apply to the main lines, as the wash-up water there is diluted by other water.

The heating contract called for an expenditure of $35,000 for the piping alone. This is a 6 lb pressure system and discharges into a vacuum of about 10 in. All of this piping is black steel.

Insulation of the Piping

All piping including the cold water lines is insulated. Steam and hot and fresh cold water lines are covered with magnesia and brine lines with built-up hair felt. The refrigerated water piping is insulated with cork. All except the latter have an outer finish covering of sewed-on canvas.

The magnesia is of course satisfactory for the steam and ordinary cold water lines, as well as the hot water. Our experience has shown that built-up hair felt is advisable for below freezing temperatures. For cold temperatures above freezing, such as the refrigerated water lines, cork is preferred because it is less bulky, is of good appearance and does not need to be covered with canvas.

All piping is painted with three coats of white lead

and oil with a gloss finish so that it is easy to keep clean. The piping is gone over periodically with a vacuum cleaner to remove dust and is scrubbed when necessary. The piping is kept just as scrupulously clean as the rest of the plant, which is essential to prevent dust and dirt from falling into products in process of manufacture.

Conserving Process Water

A great deal of process cold water is used for cooling candy and chocolate in jacketed kettles, candy slabs and for other heat exchange equipment. This is discharged by gravity after doing its work and is returned to a common collecting tank on the second floor level. This tank has a pump connection discharging to a line delivering to a building service tank on the ninth floor level which supplies water for flushing toilets. In this way the cooling water is used again before it is lost and helps to keep water costs down.

The pump that draws water from the second floor tank is float controlled and runs when that tank is full and when it is drawn down to empty automatically shuts off. It is also automatically shut off when the ninth floor tank is full by a similar float control. If both tanks are full at the same time, the one on the second floor overflows into the waste line. If there is a shortage of water in the ninth floor tank, due (for instance) to both tanks being empty, or nearly so, at the same time, there is another float control in the upper tank which automatically feeds city water into it so that there is no danger of ever being without water for flushing purposes. The clean, fresh, cold water for manufacturing, cooling and washing in the wash rooms is supplied from a second tank on the ninth floor level which is supplied direct from the city water main through a pump with automatic float control. These float controls are inspected every month, but it is very seldom that anything has to be done to them.

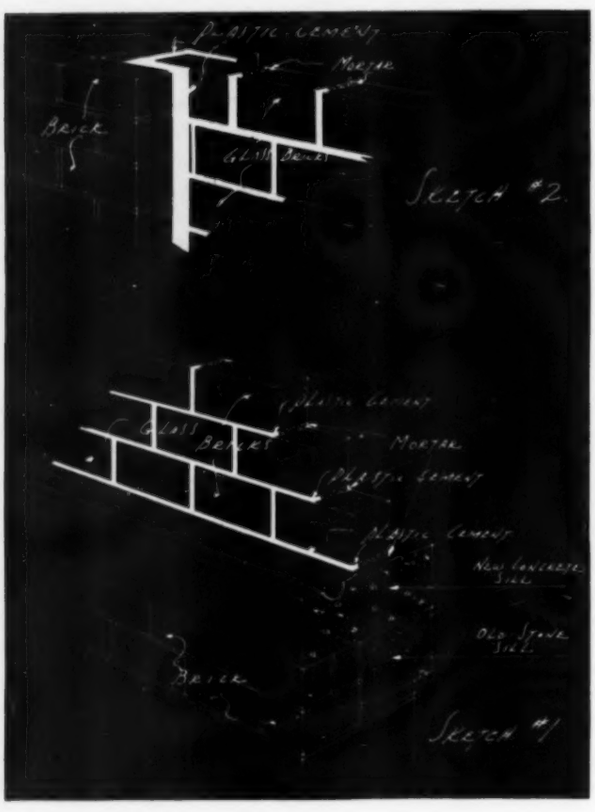
Lockwood Greene Engineers, Inc., Boston, designed the piping for this plant.

Glass Bricks Replace Windows—Lower Maintenance Costs and Reduce Condensation in Air Conditioned Plant

By L. Duckmann*

IN ORDER to prevent condensation because of the high humidities maintained, windows at the air conditioned Oscar Heineman Corp. plant, silk manufacturers, Chicago, have been replaced with glass bricks. These bricks are designed to reduce condensation, eliminate air leakage and thus reduce fuel costs, cut maintenance costs, and facilitate better lighting. So far, they have proved successful, although sub-zero weather conditions have not yet been encountered. A smaller amount of condensation is noticeable.

*Plant Engineer, Oscar Heineman Corp., Chicago, Ill.



Double-paned, wooden-sashed windows were formerly used. Steel sashes proved unsatisfactory because of rust, deterioration being more rapid than with wooden sashes. It was almost impossible to apply preservative paints between the panes of glass, hence it was necessary every few years to replace the rotted sashes.

Hollow glass bricks make use of the same principle of double panes but they eliminate either steel or wooden sashes. The solidity of the glass texture and the adhesive quality of the cement prevents moisture from soaking through the bricks and sashes, causing shaling of outer bricks and formation of dangerously large icicles.

In preparation for the installation of glass bricks, all the windows were removed from the walls leaving 36 openings each 9x14 ft. To brick up these openings with glass bricks cost $165 per opening; using the ordinary double-pane materials the cost would have been only $140 per opening, but taking into consideration the high cost of maintenance—$800 every three years for the paint job alone—eliminated, the difference is negligible.

Before laying the bricks, it was necessary to build new sills on the old ones, which had become pitted and worn uneven by moisture. The sills are 9 in. wide. As stated before, no sashes are needed. This allowed a 2 in. gutter to be formed on the interior side of the sills which is connected to a drain pipe to carry off the condensation.

The bricks themselves were laid up in a rich cement, with ¼ in. mortar between each brick and each row. Also between each row the mortar was racked out (Sketch No. 1) and filled with an elastic, waterproof plastic cement. One end of each 9x14 ft window space was left open (Sketch No. 2) to be sealed with an elastic plastic cement to allow for expansion and contraction.

The design of the bricks—vertical concave lines on one face, horizontal lines on the other—eliminates glare by diffusing the light rays. Absence of glare makes window shades unnecessary, as well as electric lights during daylight working hours which formerly had to be used when shades were lowered to shut out glare.

Heating 10,000 Hens

By Kalman Steiner*

When the owners of a building originally erected for an automobile distributor were left tenantless, a most unusual enterprise for an industrial district was decided upon. The structure was converted into a "poultry farm" . . . Not the least of the problems

involved was the ventilating and heating, for temperatures must be carefully controlled, odors kept to the minimum, and there was little experience on which to base the design. . . . Control of the fans and burners had to be arranged to prevent their bucking each other with consequent waste of fuel.

TEN thousand hens laying eggs—not on a country poultry farm but in a six story reinforced concrete factory in Chicago's industrial district. This is the achievement of a modern business enterprise which has proved the salvation of a "white elephant" real estate investment.

Originally designed and erected as a warehouse and service building for an automobile distributor, the structure proved too costly for this purpose with the result that the lease was not renewed. A satisfactory tenant could not be found for the entire building, nor could it effectively be subdivided into floor or loft space. From the necessity of realizing some sort of return from the structure, with reasonable promptness, came a decision to try an entirely new sort of business venture—and into the building were moved 10,000 tenants who pay their rent in eggs.

Each hen is provided with its private cage—clean, sanitary, well lighted, properly ventilated and heated. Food is supplied in scientifically correct amount and quality; water comes to each cage separately to give each bird a private drinking fountain! Vitamins, calories and minerals are closely regulated to assure maximum health and comfort for the chickens; and they respond by maintaining an egg-laying rate exceeding the normal.

A great amount of mechanical apparatus is needed. The cages are stacked in tiers four high, in rows ten long. There are facilities for removing the manure, which becomes valuable fertilizer. The cage floors slope into a rack outside the cage; the egg rolls into this rack to be picked up at the next collection, at which time the weight of the egg will be entered on the chicken's individual chart. The eggs must be sorted by weight, put in cartons, and crated. Food must be stored, mixed and distributed to the birds. But of all the apparatus and equipment required, none involved greater uncertainty in original design than the ventilating and heating. Poultrymen know how to feed and tend laying hens, but neither the poultrymen nor heating men know much about heating hens.

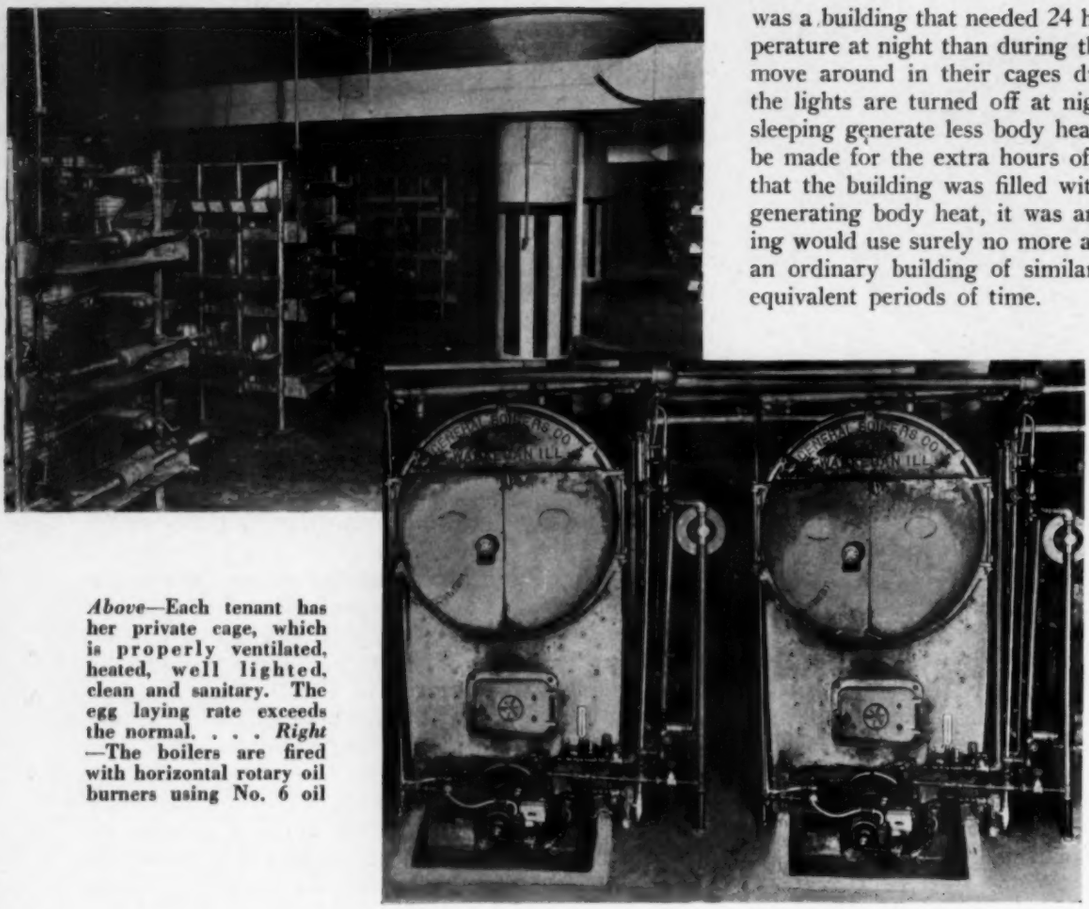
Ventilating and Heating Requirements

The upper five floors are devoted to the laying pullets, and the first floor is given over to baby chicks, and maturing chickens which have not yet started to lay. The chicks are brought in when one day old, and for the first 28 days must be kept in a room at 76 F and 50 per cent relative humidity. Then they are moved to a developing room, maintained at 72 F, for the next eight weeks. When twelve weeks old they are moved to separate cages in a room at 65 F, and remain there until they start to lay. Thereupon the now mature chickens are given cages in the upper floors, which are heated to 60 F during the day and to 65 F at night. From all the floors large quantities of foul air are removed. Hence it was necessary to provide four differing temperatures in as many parts of the building, to regulate the humidity in one part, and to remove odors from the entire building.

The building was originally equipped with a heating plant comprising two 6500 sq ft welded steel firebox boilers and 5800 sq ft of wall type steam radiation installed as an overhead, two pipe, vacuum system. The radiation had been figured for a temperature rise from —10 to 65. It was therefore necessary to increase the radiation in rooms where a temperature higher than 65 F was required.

In laying out the air exhausting system, it was felt that the experience of expert poultrymen could best be used as a guide, and it was their suggestion that on each floor there be installed two centrifugal type exhaust fans each having a capacity of 10,000 cfm. The duct system permits drawing out air uniformly from the entire floor area. The poultrymen stated that these fans should be controlled from thermostats set to cut the fans in when the room temperature rose 2 F above the the point previously determined upon as correct, the thermostats to have a 2 F differential so as to cut out again as soon as the fans brought the temperature down to normal. Since the hens throw off odors at a rate corresponding to their own body radiation, the heat they throw off can be used as an index of the quality of the air (at least so said the poultrymen).

*Ace Engineering Co., Chicago, Ill.



Above—Each tenant has her private cage, which is properly ventilated, heated, well lighted, clean and sanitary. The egg laying rate exceeds the normal. . . . *Right*—The boilers are fired with horizontal rotary oil burners using No. 6 oil

The boilers were converted to oil-firing, using horizontal rotary burners operating under full automatic control with preheating to permit burning No. 6 oil. To assure that the most important spaces received adequate heat, the thermostats of the burners were located in the chick room where a temperature of 76 F is required. In the other spaces, should the temperature rise above that required, radiators could be shut off. In this manner the radiation was balanced so that each space heated as required while the burners were in operation, and so that when the thermostats shut the burners down from the temperature in the chick room, the rest of the building had received its proportionate amount of steam.

Fuel Consumption Double the Estimate

After initial adjustments were made the poultrymen in charge were instructed in the setting of the thermostats for both the fans and the burners, and the plant was left under their supervision. As little mechanical difficulty seemed to arise, no very close attention was paid to the plant's operation during the first month of genuine winter weather. But at the end of the first month, fuel consumption was found to be about twice the amount anticipated.

So far as fuel consumption is concerned, it is not difficult to predict the amount of oil that will be burned, within 10 per cent anyway, to heat a given building used for any specific purpose during certain hours of the day for normal degree-day experience. It is true that here was a building that needed 24 hr heat, and a higher temperature at night than during the day (because the birds move around in their cages during the day, but when the lights are turned off at night they roost, and while sleeping generate less body heat). But allowance could be made for the extra hours of heating, and considering that the building was filled with live birds continuously generating body heat, it was anticipated that this building would use surely no more and possibly less fuel than an ordinary building of similar construction heated for equivalent periods of time.

A hurried survey showed nothing radically wrong with the equipment or its apparent performance. The burners worked smoothly, without smoke or carbon formation; the CO_2 content and temperature of the stack gases were normal; the fuel tank showed no leaks; an audit of fuel deliveries showed no errors.

The next step was to place an operations recorder on the job; this is a device placed in series with the oil burner motor (either burner could carry this building singly at any time and in the coldest weather) which writes a 24 hr chart of the on and off periods of the burner. Within a day, half the story was known: the burner worked almost continuously, stopping only from the pressurestat, but never from the thermostat. The next step was obvious: the recorder was placed in one of the exhaust fan circuits. It showed that the fans, too, worked almost incessantly. The complete answer was of course found in the thermostat settings.

It will be recalled that the fan thermostats work on a cycle of starting at high and stopping at low temperature. With the burner thermostat the reverse holds; the thermostat cuts in at low and off at high temperature. What happened was this. The poultrymen set the two thermostats at overlapping points. With a room temperature of 77, the burner kept running in order to boost the room to 78 so that its thermostat would cut off. Similarly, the fans kept running in a vain attempt to bring the room down to 76 so that their thermostats would cut off. The fans took the heat out of the building as fast as the burner could send it up, so fans and burner kept on running.

New Thermostat Settings, Fan Timer, Solve the Problem

This condition was quickly corrected by instructing the men in charge to be more careful in setting the instruments to avoid overlapping. The burner thermostat was arranged to start the burner at 75 and stop it at 77; the fan thermostat was set to cut in at 80 and out at 78.

Hence the two could not become interlocked and buck one another.

Immediately thereafter, another curious thing happened. The fuel consumption dropped by considerably more than 50 per cent per degree day. This time a reverse condition existed. After the burner stopped at 77 F room temperature, the birds generated and released enough heat to compensate for the building heat loss, and actually maintained the room temperature at 77, or at least allowed it to drop but very slowly. Of course, the odor became too heavy, and attendants would run the fans, manually, until the atmosphere cleared up.

The proper procedure necessary to make the plant completely automatic and still keep both poultry and their keepers comfortable and contented was now evident. A bit of research revealed that if the fans were operated 10 minutes out of every 30 the atmosphere remained fresh. So a timing mechanism was installed to control fan operation on this schedule with provision, of course, for adjusting the actual timing periods in case it developed that milder or more severe weather would require somewhat different proportioning. The burners remained under thermostatic regulation.

Of course, were a building to be erected originally for this specific purpose, or had it been possible to substitute a different type of heating plant for the one originally put in, it is possible to design a more suitable kind of heating and ventilating system. Modern air conditioning points the way. The heat should be introduced by heating air blown into the building; foul air should be removed from the building by a suitable opening through which it would be forced by the incoming fresh, warm air. Thermostatic steam valves or thermostatically controlled louvers would take care of the temperature regulation nicely.

A Field for Air Conditioning?

Aside from the need for fresh air and elimination of odors, there is another serious factor existing which vitally affects the accuracy of the temperature regulation. Should the room temperature rise much over those above described as correct, the hens respond to a natural stimulus by proceeding to molt, which means that they shed their feathers and begin growing new ones. And since eggs are not laid while molting is going on, it is apparent that molting is disastrous to egg production. So the temperature must be held within safe limits. By inference, it might seem that summer air conditioning or cooling might keep the hens fooled all year 'round and circumvent their molting at all. But the present writer is not prepared to discuss such an artificial plan for thwarting natural biological processes. An enterprising air conditioning sales engineer might investigate this.

Miniature Lake on Roof, Double Glass Walls, Cut Store Air Conditioning Load

It is estimated that 20 tons additional refrigeration capacity would be required if this roof cooling scheme were not used

WHEN C. T. Kern of the Kern Engrg. Co. was called upon to design an air conditioning system for the "modernistic" J. C. Penney Co. department store in downtown Milwaukee, unusual conditions were met. With the exception of the balcony sales floor, the building is practically of one story construction, the external height being little more than 25 ft. This presented a problem of roof cooling. The roof, incidentally, is constructed so that it can be made the floor of an additional story; the foundations are designed to carry six or more additional stories. Area of the roof is approximately 30,000 sq ft.

To cool the roof, a miniature lake two inches deep was resorted to; in cool weather, particularly when the temperature is around freezing, the water is of course drained off. City water is used for condensing purposes, the waste being pumped to the roof as required. According to Mr. Kern, about 20 tons additional refrigeration capacity would have been needed if this scheme had not been used.

Also of assistance in cutting down the air conditioning load is the use of double walls of glass. The Penney store, it is believed, has the greatest exterior area of glass of any structure in Milwaukee, about 75 per cent of the outer wall space being glass.

Two refrigeration compressors, one driven by a 75 hp motor and the other by a 60 hp motor, are installed, and about 60,000 cfm of air is circulated. Performance records show that from May to September, 1936, representing about 1,000 hr of operation, 42,440 kwhr of current was used. During the same period 457,000 cu ft of water was consumed. The space air conditioned covers a first floor 150 x 200 x 21 ft high and a basement 150 x 150 x 12 ft high.

CONTROLS

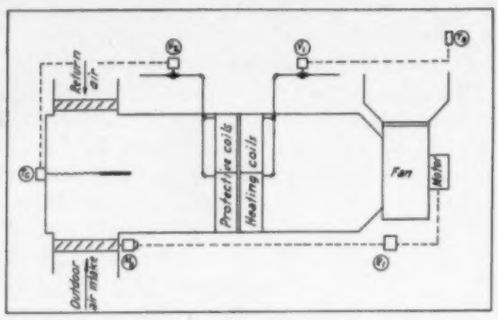
By C. L. Ringquist*

Reference Sheet 4

Heating and Ventilating

[Inasmuch as heating only, without ventilation, is generally accomplished with direct radiation, this section is devoted to describing a few control systems supplying both the heating and ventilating requirements and their control. These systems must not only supply the required amount of air for ventilation at the proper temperature but must also supply the heat necessary to offset the heat losses in the heated and ventilated space.]

System for Supplying Heating and Ventilating Requirements:



Symbols

M_D	Damper motor
R_1	Relay
T_C	Duct thermostat
T_R	Room thermostat
V_1	Modulating valve
V_2	Two position valve

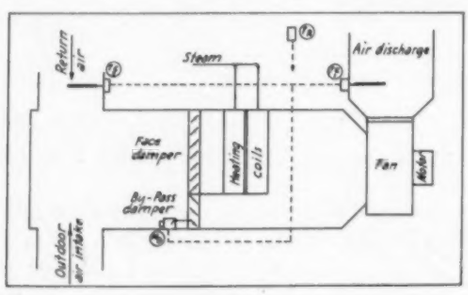
Cycle—V_2 is controlled by means of T_C which is usually set to open V_2 when the temperature of the mixture of the air falls below 35 to 40 F.

V_1 is controlled by T_R which controls the room temperature by governing the steam supplied to the heating coil.

A manually operated damper in the return air intake permits adjustment of air quantity.

The other controls are M_D controlling the damper in the outside air intake by means of R_1, which acts to open the damper in the outside air intake through M_D whenever the fan motor is started and to close this damper when the fan motor is stopped.

Heating and Ventilating System. (This system has the advantage that the air being discharged from the fan will never be below a predetermined temperature. Also, the arrangement of face and bypass dampers prevents extreme variations in temperature in the heated and ventilated space):



Symbols

M_D	Damper motor
TC_1	Duct thermostat
TC_2	Duct thermostat
T_R	Room thermostat

Cycle—TC_1 acts as low limit control and prevents introduction of too cold air into room. TC_2 determines amount of heat added to air by passing more or less through heating coils by adjustment of the face and bypass dampers through M_D. TC_1 assumes command only when action of TC_2 would cause low temperature air to be discharged from fan.

Room thermostat T_R may be substituted for duct thermostat TC_2 if desired.

*Air Conditioning Department, The Trane Co., La Crosse, Wis.

Although data on automatic controls for heating, humidifying, dehumidifying, ventilating, cooling and complete air conditioning may be had from numerous sources, information on groups of controls applicable to various types of systems is not so readily available. The author has therefore diagrammed typical control layouts, with each of which is given an explanation of the control cycle. . . . For the purpose of illustration, central fan coil types of systems are used; the control arrangements described are equally applicable to units built up to perform the same functions. . . . Types of systems covered by this series include humidifying; ventilating; heating and ventilating; heating, ventilating and humidifying; cooling, dehumidifying and ventilating; cooling, dehumidifying, ventilating and humidifying; heating, ventilating, dehumidifying and cooling; heating, ventilating, dehumidifying, cooling and humidifying; and zone control systems.

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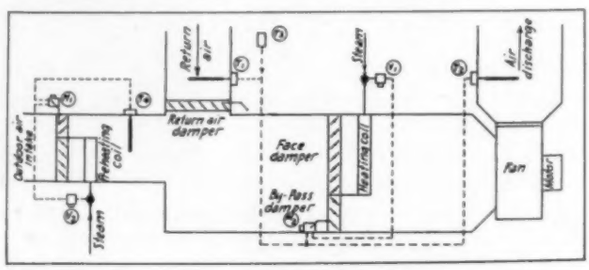
A More Elaborate Design of Equipment and Controls, for More Accurate Control and More Efficient Operation:



Symbols

M_1	Damper motor
M_2	Damper motor
T_1	Duct thermostat
T_2	Duct thermostat
T_3	Room thermostat
T_4	Duct thermostat
V_1	Modulating valve
V_2	Modulating valve

Cycle—T_4 acts to control amount of outside air passing through or around preheating coil, thus maintaining constant entering air temperature from this duct into the plenum chamber. Face and bypass dampers are operated by M_1 which in turn is controlled by T_4. Auxiliary switch on M_1 closes V_2 whenever face damper is entirely closed. T_1 (or as an alternate, T_3) controls M_2 so as to regulate the quantities of air passing through or around main heating coil, thus taking care of room heating requirements. A second auxiliary switch on M_2 acts to close V_1 whenever all the air is being bypassed. T_2 acts as low limit control and assumes control of M_2 only when air would be introduced into the room at a lower temperature than called for by T_2.

The return air damper is manually set to maintain a definite amount of recirculated air.

Field Tests Check Analyses of Stresses and Change of Shape in Expansion Bend

In modernizing Conners Creek power plant, a main steam cross-over of unusual length and in the form of a large expansion bend was installed. In addition to the usual stress analysis, the bowing of this line when heated to 850 F became of such magnitude as to require careful analysis to insure that the piping had adequate clearance from the building wall and columns in the hot position. . . . All flexibility analyses in the initial stages of design were carried out by the "ready-made-solution" method, using curves and tables. An analysis of the stresses, forces and movements in the final structure was made by the grapho-analytical method. After the line was placed in service, opportunity was afforded to take actual field measurements of how far and in what direction various points of the line traveled from the cold to the hot position. . . . The results were a satisfactory confirmation of the design figures, both with respect to the magnitude and to the direction of movements

By E. A. Wert* *and* S. Smith*

PIPING systems—upon whose reliability the operation of modern plants depends to a very large extent—may be considered as satisfactory only when they combine maximum utility, economy and safety. Hence the necessity for providing adequate flexibility becomes a prime safety feature, for in this particular phase of design a complete analysis is made of the forces at the anchor points, along with the movements, bending moments, and stresses in the pipe wall at all parts of the structure as set up by the thermal elongation of the pipe.

The adoption of a layout for the 650 lb main superheated steam piping in which there is an exceptionally long cross-over, extending all the way from the north to south end of the plant and located entirely within the second gallery of the turbine house at Conners Creek, created an unusual problem in designing for flexibility. With steam at 850 F flowing through the line, the expansive movement of the pipe amounts to over 7 in. per 100 ft. This, combined with limited space of about 15 ft in an east and west direction available for the installation, necessitated a careful flexibility analysis to be sure that elongation of this order could adequately be provided for in a 236 ft run of pipe.

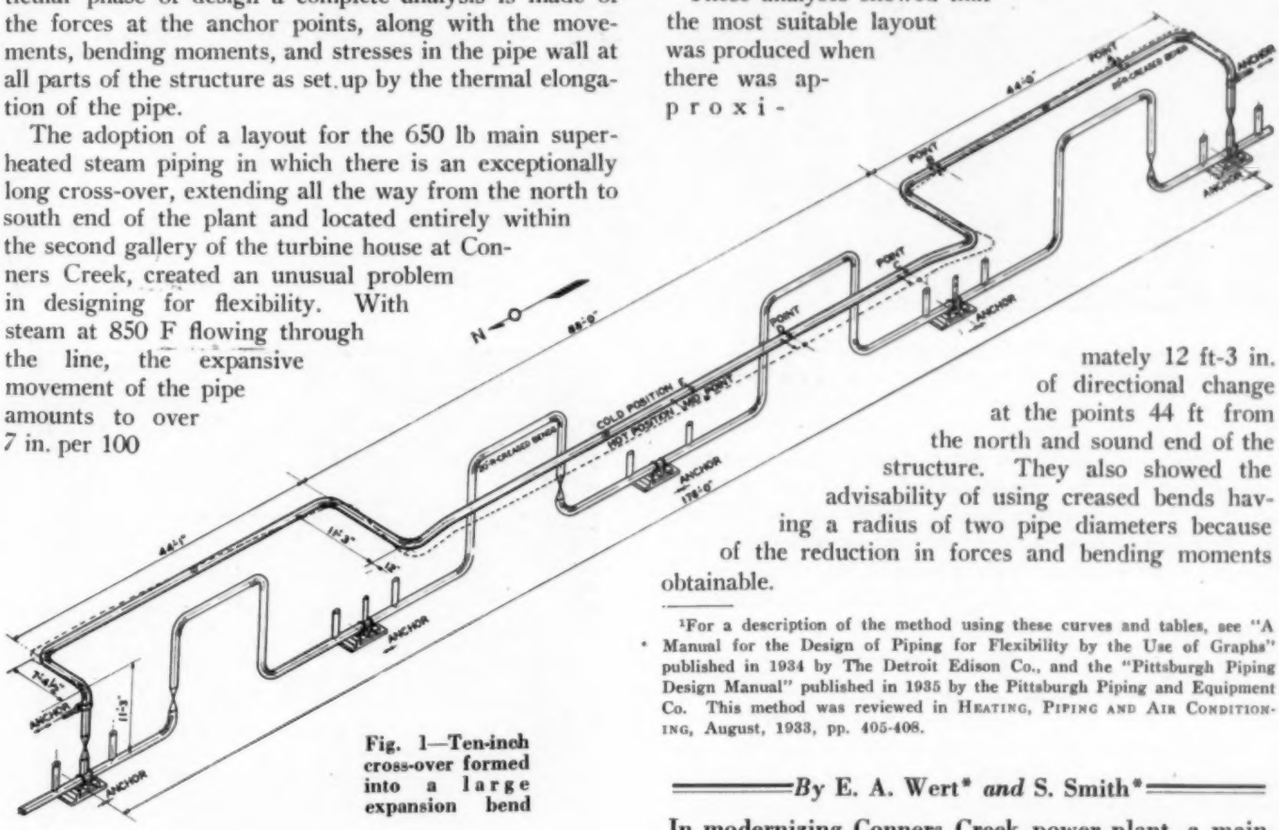


Fig. 1—Ten-inch cross-over formed into a large expansion bend

Designing for Flexibility

The maximum allowable combined stress (the sum of the longitudinal bending and pressure stresses) for this problem was limited to 15,000 lb per sq in. in the pipe removed from welded or bolted joints, and 10,000 lb per sq in. in the pipe adjacent to welded or bolted joints.

In the development stage of this cross-over, all analyses were made by the use of curves and tables.[1] The first step in each analysis was to assume the upper part of each vertical leg anchored against all movement. Then, by the curves and tables, a rapid determination was made of the suitable lengths of the elements of an expansion U-bend which would provide adequate flexibility.

These analyses showed that the most suitable layout was produced when there was approximately 12 ft-3 in. of directional change at the points 44 ft from the north and sound end of the structure. They also showed the advisability of using creased bends having a radius of two pipe diameters because of the reduction in forces and bending moments obtainable.

[1]For a description of the method using these curves and tables, see "A Manual for the Design of Piping for Flexibility by the Use of Graphs" published in 1934 by The Detroit Edison Co., and the "Pittsburgh Piping Design Manual" published in 1935 by the Pittsburgh Piping and Equipment Co. This method was reviewed in HEATING, PIPING AND AIR CONDITIONING, August, 1933, pp. 405-408.

*Drafting and Surveying Bureau, The Detroit Edison Co., Detroit, Mich. All republication rights reserved by the authors.

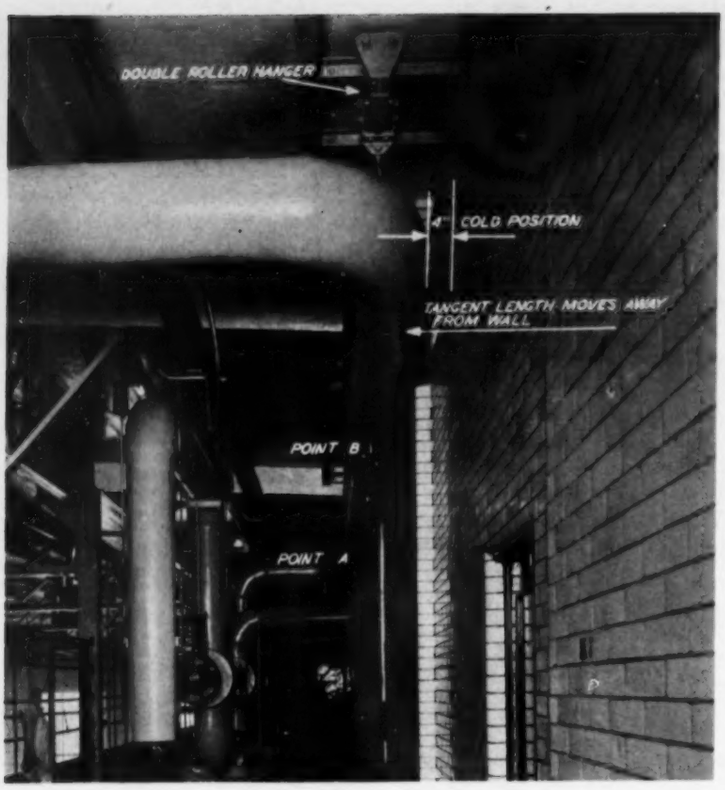


Fig. 2—Part of the 10 in. main steam cross-over showing the 44 ft tangent moving away from wall

In order to install this cross-over in the space prescribed, and still to have the required amount of directional change, it was necessary to lay out the line, except for the offset shown in the 88 ft tangent, as indicated in Fig. 1. (The necessity for the offset is explained later.) The anchor at the top of each vertical leg eliminates any large direct bending at the valve section.

Movement of the Structure

In the present article the authors have extended their methods for solving flexibility problems through the use of graphs to include movements or displacements in addition to the stresses, forces, and bending moments heretofore considered. The use of a group of curves as shown in Fig. 5 provides a similar solution for the movements in an expansion U-bend at right angles to the force. This figure is from a series of yet unpublished graphs dealing with this same analysis for various other types of structures.

The use of these curves is illustrated here by showing how they were employed in this problem to determine the approximate amount and direction of the travel at various points in the structure. In order to be able to apply these curves to this particular problem, it was assumed that the extreme end of each of the 44 ft tangents was restrained against all movement. By this assumption the structure became similar in shape to an expansion U-bend as shown in Fig. 5, and the solution, determining $\triangle z_1$ and $\triangle z$, was carried out as follows:

When the line is heated to 850 F, the total horizontal expansion ($\triangle x$) equals (176×0.0718) or 12.64 in. The value of $W/H = 88/12.25$ or 7.18, and $L/W = 176/88$ or 2. The value of $\triangle z_1/\triangle x$ is found by projecting vertically from the point 7.18 on the abscissa scale of the left hand family of curves until it intersects the $L = 2W$ curve and read the ordinate value. $\triangle z_1/\triangle x = 0.73$ or $\triangle z_1 = 9.2$ in. In a similar procedure by the use of the right hand family of curves (Fig. 5) the value of $\triangle z/\triangle x$ is found to equal 1.56 or $\triangle z = 19.7$ in. When applied to the actual pipe line $\triangle z_1$ represents the movement away from the wall at points located nearly at B and $\triangle z$ the movement toward the west building columns at the mid-point of the structure (see Fig. 1).

In the design of this line 6¼ in. was allowed for cold spring, obtained by pulling up a gap between points A and B, Fig. 1. Computations indicated that this would distort the line so that points B and E would move 4 and 10 in., respectively, toward the wall. Accordingly, in estimating clearances due account was taken (1) of the fact that the line would be cold sprung, and (2) that the expansive movement would necessarily be measured from the cold sprung position to the hot position rather than from the neutral position

Fig. 3—A large portion of the 10 in. main steam cross-over showing the bowing of the 88 ft tangent after the change of shape occurred

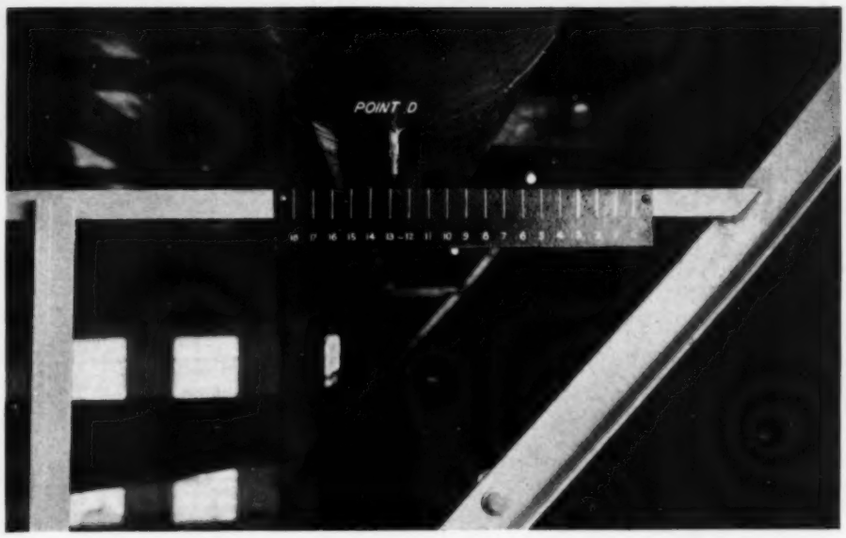


Fig. 4—Method employed to observe action of the cross-over, showing the large amount of movement at the point *D*

to the hot position. Incidentally, the cold spring contemplated involved a maximum bending stress in the pipe wall of approximately 5000 lb per sq in. and a force at the anchorage of 3000 lb, both in the opposite direction from the corresponding stress and reaction existing in the hot position.

Since the reaction of cold spring is the opposite of that due to thermal expansion, it might be assumed that its amount can be deducted from the total thermal elongation to be absorbed by the structure. While an analysis based on this assumption would give lower maximum bending stresses and forces, it would determine only the partial travel of each point in going from the cold to the hot position. In order to obtain the true total movement at every point it is absolutely necessary to use in the analysis the maximum thermal elongation, whether or not this total movement takes place all on one or on both sides of a neutral position.

In the authors' flexibility analyses, the effect of cold spring is neglected on the grounds that it is indeterminate because there is always the possibility that the pipe may take a permanent set or slide through the anchors, and also because the contour of the line may be such that the cold spring is lost in its erection. Therefore, in this particular problem the cold position of the line refers to its location after it had been cold sprung. Using the dimensions of the structure as required by the stress analysis, there remained in the cold condition only 4 in. clearance between the pipe covering and the wall, Fig. 2, and 9 in. clearance between the pipe covering of the 88 ft tangent and the building columns. Visualizing the actual clearances and the expected movements, the necessity for offsetting the 88 ft tangent as shown in Figs. 1 and 3 was quite apparent.

Thus a complete flexibility analysis for this problem was quickly and simply obtained by the use of curves and tables. It should be recognized, however, that a solution from curves and tables does not give a rigorously correct answer since the actual shape and method of anchoring differ somewhat from an ideal expansion bend. However, it does serve as a ready means for ascertaining whether a design is at all feasible before spending time on more exact and tedious methods.

Grapho-Analytical Analysis

For this problem it was necessary also to know, in order to properly design and install the multiple rolling hangers, the magnitude and direction every point of the line traveled in going from the cold to the hot position. Because of this, and the fact that the use of the curves did not give a rigorous solution, a complete flexibility analysis for the cross-over as shown in Fig. 1 was made by the grapho-analytical method.[2]

The analysis showed the following results: (1) the magnitude of the reacting force is equal to 4800 lb; (2) the maximum combined stress is equal to 13,600 lb per sq in.; (3) maximum bending moment is located at the junction of the 88 ft tangent and the creased bend. The maximum combined stress in any welded joint does not exceed 10,500 lb per sq in. The analysis of the movement at the points shown in Fig. 1 indicated that the movement at point *A* would be ⅜ in. toward the wall, at point *B*, 6¼ in. away from the wall, and at points *C*, *D* and *E*, the movement would be 12⅜, 17⅞ and 18½ in. respectively toward the columns.

These computations clearly indicated that the lengths of the elements of the structure as determined by the graphical method were substantially in agreement with the longer method of analysis. This was also true of the movement at the points determined by the use of the curves of Fig. 5.

Test Procedure

The smallness of the clearances, the large east and west movements indicated by the computations, and the desirability of making a direct comparison between the theoretical and actual movement of a commercial pipe installation justified the tests conducted to determine the movements of this cross-over when in service.

After the line was erected and the last joint finished, but before the covering was applied, points *A*, *B*, *C*, *D* and *E* were carefully located on the center of the bottom of the pipe. A small rod long enough to extend through the covering and pointed at the outer end was welded to the pipe at each of these points. At *A* and *B* plumb bobs were attached to locate the points on the floor, their location in the cold position being established by means of brass screws driven into the floor. In heating up the line, the amount of movement was found by measuring the distance between the point established on the floor and the new position of the plumb bob.

At points *C*, *D* and *E*, the amount of the movement was read directly on a scale attached to the building steel

[2]See Chapter VII (2nd edition) of the "Piping Handbook," by Walker and Crocker.

just below the bottom of the measuring rods, Fig. 4. The scale was graduated in inches, the cold or zero position of the pipe being indicated by the letter "C." Fig. 4 shows the position of the pipe at *D* when the change of shape of the structure caused this point to move approximately 13 in. closer to the columns.

The calculated or expected movements and the actual movements, as observed at various points in the line when operating at 850 F temperature and 650 lb per sq in. pressure, are shown in Table 1.

Because conditions encountered in a commercial piping installation do not always conform absolutely to those theoretically assumed, it is only natural to expect at some points in the line a considerable discrepancy between theoretical and actual results. For this problem the largest discrepancies were found at points *A* and *B*, in all probability due to the following: It is practically impossible to construct anchors to maintain 100 per cent restraint and without a doubt this condition holds true for the anchor at the junction of the cross-over and manifold.

A rolling feature is incorporated in the design of this anchor which permits the entire header to move in an east and west direction approximately ¾ in.; this makes it possible for the movement of the boiler leads and of the cross-over itself (when in operation) to set up a rotation at this point in a direction which would cause the cross-over, as a whole, to move toward the wall. This rotation would have its greatest effect on the points *A* and *B*. In this contention, it should be noted that a rotation of this nature, at the anchor points of, say, half of one degree, could cause a movement toward the wall of 0.78 in. ($0.00873 \times 90 = 0.78$) at point *A*, and 3.83 in. ($0.00873 \times 438 = 3.83$) at point *B*.

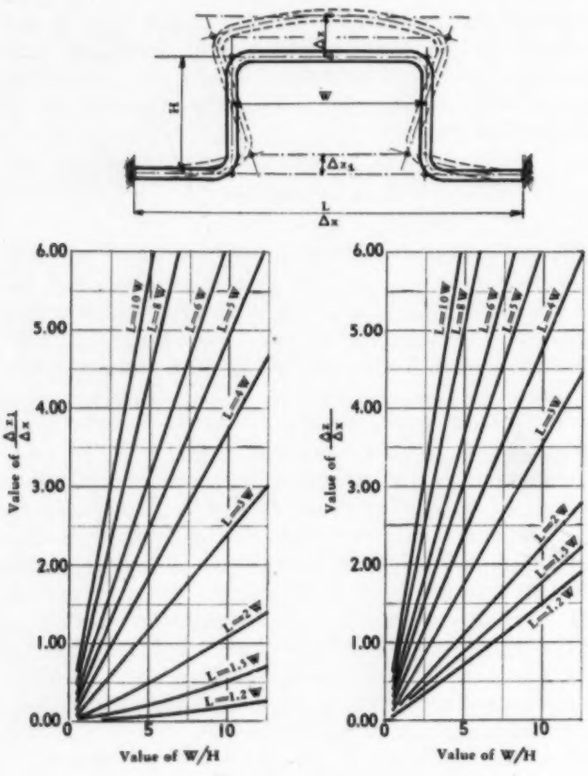


Fig. 5—Ratio of movements △ *z* and △ z_1 to total horizontal expansion △ *x*

(From a series of unpublished graphs)

Table 1

Point (See Fig. 1)	Curves Fig. 5 Amount, In.	Grapho-Analytical Amount, In.	Grapho-Analytical Direction	Test Amount, In.	Test Direction
A		3/8	Toward wall	1½	Toward wall
B		6¼	Away from wall	3	Away from wall
△z_1	9¼	9⅝	Away from wall		
C		12⅜	Toward bldg. cols.	8¾	Toward bldg. cols.
D		17⅞	Toward bldg. cols.	14	Toward bldg. cols.
E	19¾	18½	Toward bldg. cols.	14½	Toward bldg. cols.

[a]Results as shown in Fig. 5 pertain to an ideally shaped expansion U-bend.

Supporting the Line

How properly to support the cross-over was given careful consideration, particularly since the movements of the line from the cold to the hot position were known to be of large magnitude. Properly designed hangers and vibration dampeners were made possible because, from the flexibility analysis, the magnitude and direction of travel of every point in the line was ascertainable.

Fig. 6 shows the type of hanger developed for supporting this structure. The multiple rollers used are original in design.

Due to the arrangement of the building steel in the bay where this cross-over is situated, it was possible to install the supports to which the hangers were to be attached to run in an east and west direction (Fig. 2.) This worked to advantage because, since the analysis showed that the larger movement at practically every point was in an east and west direction, it was possible to design the hangers so that this movement would be absorbed by the top rollers; this in turn permitted a smaller carriage, avoiding thereby any excess weight which might have had some influence on the action of the rollers.

In keeping the dimensions of the carriages to a minimum, it was necessary after the line had been cold sprung to adjust their location. With the line in operation, the hangers were observed performing very satisfactorily, remaining in a vertical position at all times. Note the position of the hanger in Fig. 3 after it had moved 8 in. west and 3 in. south.

Inasmuch as the vibration of the line under load would add to the already existing stress an additional repeated stress, effort was made to develop an improved type of vibration eliminator; Fig. 3 shows the type adopted. This design consists primarily of two springs mounted on a small diameter pipe, one end of which is attached to the line itself. A support, designed to permit swivel action, was placed between the springs and attached to the building steel. As the periods and magnitudes of the vibration depend upon the various operating conditions, a method was employed whereby a modification (or the desired dampening effect of the springs) could be obtained by adjusting the location of the spring seats, which are on the extreme ends of both springs and screwed to the supporting pipe. In this design the vibration eliminator can operate at all times with a minimum of spring action.

[*Concluded on page* 671]

Graphical Method of Determining Finned Coil Capacities Described

By E. P. Wells*

It is the author's purpose to clarify the factors affecting the performance of finned dehumidifying coils, to show how the complete performance of a coil may be predicted from a few tests, and to describe a simplified graphical method of presenting coil data for the use of application engineers . . . . His article is based upon several years of laboratory research work on air conditioning coils.

AIR conditioning application engineers frequently find it difficult to estimate accurately the capacity which will be obtained from a particular dehumidifying coil under a given set of conditions of refrigerant temperature, air velocity, entering air temperature, and moisture content of entering air. It is particularly difficult to determine the amount of moisture that will be removed. It is therefore the purpose of this article to clarify the factors affecting coil performance; show how coil manufacturers may predict the complete performance of a coil from a few tests; and to describe a simple graphical method of presenting coil data for the use of application engineers.

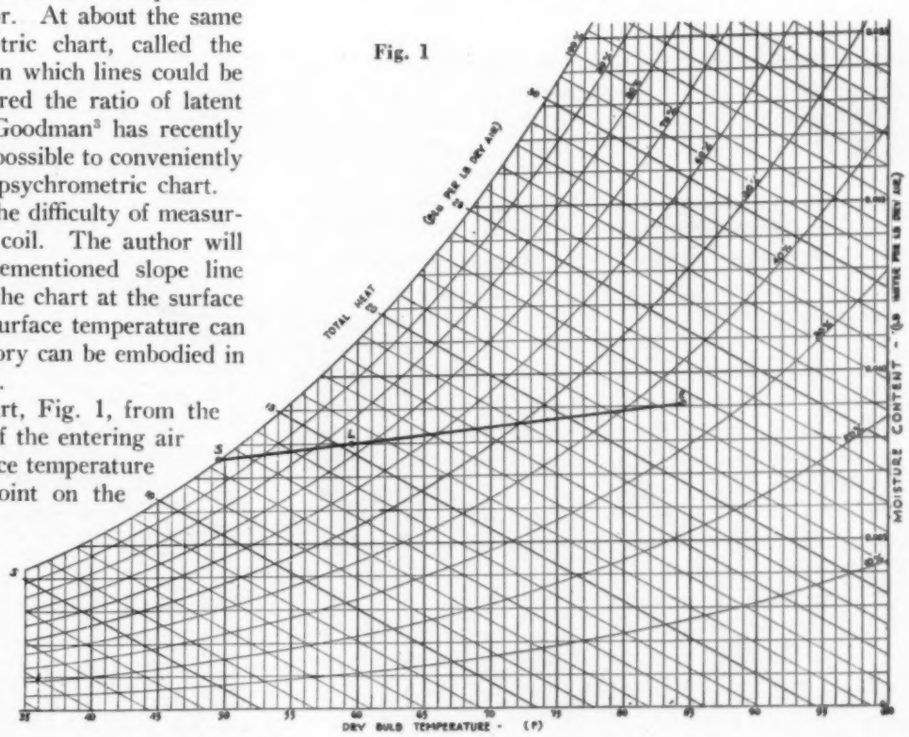
The analysis of coil performance given is consistent with the work of several earlier writers. Chester Scanlan[1] was one of the first to show that the wet bulb temperature of entering air, rather than dry bulb temperature, was a controlling factor. W. L. Knaus[2] has given calculations which show that the surface temperature of a coil is another principal factor. At about the same time, a new type of psychrometric chart, called the "Psychrograph" was developed, on which lines could be drawn, the slope of which measured the ratio of latent to total heat removed. William Goodman[3] has recently devised a "ruler" with which it is possible to conveniently draw slope lines on the ordinary psychrometric chart.

There has remained, however, the difficulty of measuring the surface temperature of a coil. The author will endeavor to show that the aforementioned slope line intersects the saturation curve of the chart at the surface temperature of the coil, that the surface temperature can be found by test, and that the theory can be embodied in a simple, consistent rating method.

If a line be drawn on the chart, Fig. 1, from the point representing the condition of the entering air to the point representing the surface temperature on the saturation curve, some point on the line will represent the condition of the air leaving the coil. The exact position will depend upon the depth of the coil, the number of fins per inch, and the air velocity. The slope of the line will be a measure of the ratio of latent to total heat removed. The actual quantity of heat removed can be measured by the ratio of the length, *E-L* to the length *E-S*.

The chief obstacle in accurately determining the amount of moisture that is removed by the finned dehumidifying coil lies in the evaluation of the surface temperature. Physical measurement of the temperature by means of thermo-couples is practically impossible, due to the variation in temperature from the tube to the edge of the fin, and from the inlet of the coil to the outlet. Furthermore, the pressure drop of the refrigerant produces another variation. The method of measurement outlined in this article consists in finding the practical, *effective*, surface temperature, regardless of how

Fig. 1



*Research Engineer, Universal Cooler Corp., Detroit, Mich.

[1]*Refrigerating Engineering*, Vol. 27, p. 197.

[2]*Refrigerating Engineering*, January, 1935.

[3]HEATING, PIPING AND AIR CONDITIONING, August, 1936.

List of Symbols

A	Face area of coil, sq ft
a	External surface of fin and tube, sq ft/sq ft of face area
b	Empirical constant
d	Empirical constant
D_1	$t_1 - t_s$
D_2	$t_2 - t_s$
$f(v)$	A function of the velocity of the refrigerant, form $f(v) = b\,Q^n$
G	Mass velocity of dry air, lb/hr/sq ft of face area
h	Total heat content of air, Btu/lb of dry air
h_s	Total heat content of air saturated at t_s, Btu/lb of dry air
K	Heat transfer coefficient Btu/hr/sq ft/F
$M.T.D.$	Logarithmic mean temperature difference
m	Moisture content of air, lb/lb of dry air
m_s	Moisture content of air saturated at t_s, lb/lb of dry air
n	Empirical constant
Q	Total heat transferred by entire coil, Btu/hr
Q_s	Sensible heat transferred by entire coal, Btu/hr
Q_L	Latent heat transferred by entire coil, Btu/hr
R	Ratio of removed to "removable" heat
s	Specific heat of moist air, Btu/lb of dry air
t	Temperature, F
t_s	Coil effective surface temperature, F
u	Empirical constant
w	Area of inside surface of tube, sq ft/sq ft of face area
$\triangle t$	(Delta t) Surface temperature minus refrigerant temperature
	Subscript 1 Air entering coil
	Subscript 2 Air leaving coil
	Subscript r Refrigerant

it may differ from any theoretical value. By running six tests, it is possible to predict the complete performance of a coil within the range of temperatures normally used.

Mechanism of Heat Transfer

It is a popular concept of heat transfer that if air enters a coil at 80 F and leaves at 70 F, having been cooled by a surface of 60 F, then every particle of the air must have been cooled to 70 F. Such is not a fact, however. Instead, *half* of the particles of air are cooled to 60 F and half are unchanged at 80 F. The mixture reaches equilibrium at 70 F.

Proof of this is given by the amount of moisture removed. Assume further that the air entering the coil has a dewpoint of 70 F. If the popular concept were true, the air would leave the coil saturated at 70 F. Instead, it leaves at a dewpoint of approximately 65 F, which is an average of the 60 F dewpoint of those particles that contacted the surface and the 70 F dewpoint of those particles that did not contact the surface. Speaking exactly, the leaving air will have a dewpoint corresponding to that moisture content which is an average of the moisture contents of air saturated at 60 and 70 F.

In forced convection, diffusion of heat through the air cannot be an important factor because of the short time involved. The amount of sensible and latent heat removed depends upon the number of molecules which contact the cool surface per unit of time. If, in each ten molecules of air there is included a molecule of water vapor, heat will be removed from the two gases in the ratio of ten to one (corrected for the heat bearing capacity of each). It appears consistent with test results to say that each molecule of air that touches a cool surface attains the exact temperature of that surface. The great difference between the mass of a molecule of air and mass of the fin should make this hypothesis tenable.

When a pound of air has completely contacted a cool surface, 0.24 Btu has been removed for each degree of original temperature difference. Since the time of contact of air passing through a coil is usually not long enough to enable each molecule of air to touch the surface, the average temperature of the air when it leaves the coil is higher than the temperature of the coil surface.

Each molecule of water vapor that is mixed in with the air will also attain the surface temperature, upon contact, and each pound of vapor will give up 0.47 Btu for each degree of temperature drop. If the surface is cool enough, the vapor will condense, and give up over 1000 Btu per lb, as well as some heat of the liquid. However, since the water vapor is uniformly mixed with the air, there will be a definite ratio between the number of water molecules and the number of air molecules that will touch the surface at a given time. The ratio of "water heat" removed, to "air heat" removed, therefore, will be determined by the relative weights of each, and the heat storage capacity of each, above the surface temperature. This explains the importance of determining accurately the surface temperature. It is of added importance in dehumidification because the temperature of condensation of the water vapor is often but a few degrees above the surface temperature, and the latent heat of condensation is so large in proportion to the sensible heat of air, that a large percentage of error in predicted capacity will result from a small error in the calculated surface temperature.

Removable Heat

It follows that if a pound of air (with its included water vapor) were kept long enough in contact with a surface of constant temperature, the difference between the total heat content of the air in its original condition and the total heat content of the mixture at surface temperature would be the amount of heat that would be removed. Since air passes quickly through a coil, less than this maximum "removable" amount of heat is actually removed. The ratio of "removed" to "removable" heat has been found by test to be strictly a function of time,—or of its equivalent, air velocity. The same ratio is obtained whether the ratio is calculated in terms of total heat, water vapor heat alone, or air heat alone. "Water vapor heat" will hereafter be termed "latent heat," because the sensible heat of water vapor is comparatively small and can be included with the air, under the term "sensible heat." Expressed mathematically:

$$R = \frac{h_1 - h_2}{h_1 - h_s} = \frac{m_1 - m_2}{m_1 - m_s} = \frac{t_1 - t_2}{t_1 - t_s} = \text{a function of air velocity.} \quad \text{Eq. 1}$$

(see list of symbols)

It should be noted that $(m_1 — m_2)$, multiplied by the latent heat of water vapor (approximately 1060 Btu per lb), equals the latent heat removed. Also $(t_1 — t_2)$, multiplied by the specific heat of moist air, gives the sensible heat removed per pound.

The validity of the ratio R is shown by the following Equation 16, which is developed in Addendum I, and which relates R to the conventional coefficient of heat transfer K and to air mass velocity, G.

$$K = \frac{0.564\,G}{a} \log_{\epsilon}\left(\frac{1}{1-R}\right)$$

In this equation, K can be combined with G, as it is generally known that the surface coefficient of heat transfer is a function of air velocity, of the form $K = bG^n$, (Eq. 2) where b and n are constants. Substituting this equation into Eq. 16, and using new combined constants d and u, we obtain:

$$\log_{10}\left(\frac{1}{1-R}\right) = \frac{d}{G^u} \text{ or, } \log_{10}(1-R) = -\frac{d}{G^u} \qquad \text{Eq. 3}$$

The curve of this equation when plotted on semi-log paper is shown in Fig. 2.

The graphical method of finding R vs. G from tests will be described in connection with Fig. 2. Tests at two different air velocities will give values of R and G which can be substituted into Eq. 3. Solving the simultaneous equations will evaluate constants d and u, so

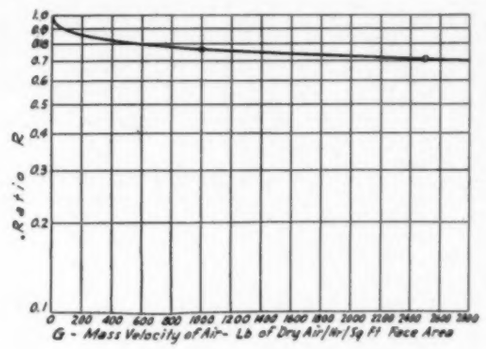


Fig. 2

that the entire curve of Fig. 2 can be drawn by assuming other values of G. Of course, the curve can also be drawn without using Eq. 3, by running tests at three or more air velocities, and plotting the values of R obtained graphically from Fig. 3. This latter method should be used in case the coil has peculiar characteristics which do not give consistent results mathematically .

Values of R can also be obtained from Eq. 18, in Addendum II. This equation involves sensible heat only, and should be used to check the accuracy of Fig. 2.

Finding the Surface Temperature

It can reasonably be deduced from the original hypothesis that, if the dewpoint temperature of the entering air equals the surface temperature, no moisture will be condensed. The dewpoint can therefore be used to evaluate the surface temperature. It has been found by test that if the dewpoint of the air entering a coil be gradually reduced, the moisture removed by the coil will finally be reduced to zero, and the author has termed the zero point: "Effective surface temperature." The surface temperature can be found by plotting the moisture content of entering air vs. moisture removed, in lb per lb of air, as shown in Fig. 3. The following factors

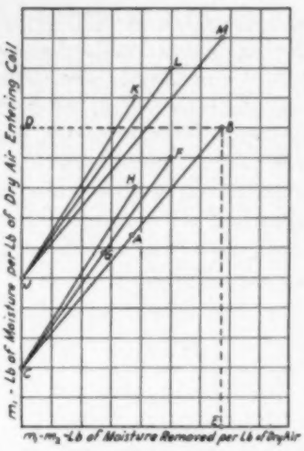


Fig. 3

must be held constant when plotting each line: wet bulb temperature of entering air, air velocity, and refrigerant temperature. Tests for each line must be run at various relative humidities (two tests such as A and B are sufficient) and a straight line can be drawn between the points. Extending the line to the point of zero moisture removed, point C, gives the moisture content of saturated air which will have a dewpoint equal to the effective surface temperature.

In Fig. 3, subtracting C from D gives the maximum moisture removable, for air entering the coil under condition B. This value times 1060 gives the maximum latent heat removable. Since value $E \times 1060$ equals latent heat removed,

$$\frac{E \times 1060}{(D-C) \times 1060} = R \text{ (ratio of removed to removable heat)}$$

R can now be plotted in Fig. 2 against the air velocity prevailing during the test. Next, it is necessary to run two more tests, F and G, at a different air velocity, but using the same values of total heat removed and refrigerant temperature that were used for tests A and B. It is necessary to use a different wet bulb temperature than was used for tests A and B, in order to keep the value of total heat removed the same. Plot the moisture removed in tests F and G as shown in Fig. 3. Connect the points with a straight line, which should pass through point C. A new value of ratio R can now be computed from line C-F, to help to construct the curve of Fig. 2. Two different velocities should be enough to construct Fig. 2, velocities of 1000 and 2500 lb of dry air per minute per sq ft of coil face area being recommended.

The success of the method depends upon keeping the surface temperature constant for all tests that are run to determine point C.

The surface temperature will be constant if the refrigerant temperature and total heat removed by the coil are kept constant. This can be shown to be true as follows:

Heat transferred from the refrigerant to the tube (and fin) depends upon the temperature difference and the velocity of the refrigerant. Mathematically expressed:

$$\frac{Q}{A} = w\ (t_s - t_r)\ f(v) \qquad \text{Eq. 4}$$

Since Q determines the rate of flow of refrigerant, it can be said that $f(v)$ is fixed by Q, and that v is probably an exponential function of Q. Q and $(t_s - t_r)$ are therefore the only remaining variables, and they can be said to be simple exponential functions of each other. Theoretically, absolute temperature may be another factor. It affects the velocity of the refrigerant by changing the density. It also affects viscosity. However, the author's tests with refrigerant temperatures between 35

and 50 F did not reveal any importance of this factor.

The difference between *tube* temperature and effective coil surface temperature is also a function of total heat transferred, since only the constant coefficient of heat transfer of the metal is involved. Therefore, we are justified, for practical purposes, in including this temperature drop with the temperature drop from tube to refrigerant, and in using in Equation 4 the same symbol, t_s, that was used in Eq. 1.

$(t_s - t_r)$ will hereafter be termed *delta t*, or $\triangle t$.

$\triangle t$ can be obtained from Fig. 3, it should be recalled, by finding on a psychrometric chart the temperature t_s of saturated air corresponding to the moisture content of point C, and subtracting from this the refrigerant temperature, t_r.

The lines converging at C of Fig. 3 can be duplicated at any level by changing the refrigerant temperature; for example, the lines intersecting at point J must all represent one refrigerant temperature, and one value of Q.

Lines J-M and C-B are parallel, having been made at the same air velocity, namely 2500 lb of dry air per hr per sq ft of face area. Similarly J-K is parallel to C-H. If the test points plotted in Fig. 3 are all made at one value of Q, then $\triangle t$ computed from point J will equal $\triangle t$ computed from point C.

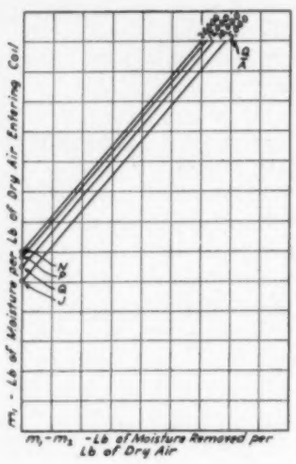


Fig. 4

To determine the variation of $\triangle t$ with Q, another family of lines, all parallel, must be plotted as shown in Fig. 4. Each line represents a different wet bulb temperature of entering air but the air velocity and refrigerant temperature are constant for all points used to form the lines. Various values of $\triangle t$ can be computed from the intersections of these lines with the vertical ordinate, and a new graph, $\triangle t$ vs. Q/A, can be plotted as a straight line on log paper, as shown in Fig. 5. Since the line is straight, only two points of Fig. 4 are needed to draw Fig. 5.

Final Results

From Figs. 2 and 5, the complete performance of a dehumidifying coil can be predicted, for any combination of conditions. For example, if it is desired to obtain a certain capacity from the coil, the first step is to divide Q/A by the air velocity, G, to determine the amount of heat removed per lb of air handled. Divide this by R, obtained from Fig. 2. This will give the maximum removable amount of heat per lb, which, subtracted from the heat content of the entering air, will give the heat content of air at t_s. From Fig. 5, find $\triangle t$. Subtract $\triangle t$ from t_s to obtain the refrigerant temperature required to give the capacity desired. Expressed mathematically

$$Q = (h_1 - h_s)\ R\ G\ A \qquad \text{Eq. 5}$$

Similarly, to obtain the latent heat removed, subtract the moisture content per lb of dry air, saturated at t_s, from the moisture content of the air entering the coil. Then multiply by the ratio R, by the weight of air handled, and by the latent heat per lb of vapor, thusly:

$$Q_L = 1060\ (m_1 - m_s)\ R\ G\ A \qquad \text{Eq. 6}$$

The sensible heat removed can be obtained by subtracting the latent heat from the total heat:

$$Q_S = Q - Q_L \qquad \text{Eq. 7}$$

or by using the relation:

$$Q_S = s\ (t_1 - t_s)\ R\ G\ A \qquad \text{Eq. 8}$$

Graphing the Coil Capacity

Fig. 7 shows one method by which coil capacity data can be presented graphically, and by which practically all use of formulas is avoided.

Use of the graph is indicated by a dotted line, which represents the data of Test No. 1. Note that 18,000 Btu per hr, total heat removed per sq ft, corresponds to a $\triangle t$ of 9.6 F (scale at the top). Adding 9.6 to the known refrigerant temperature of 40 F, gives 49.6 F, surface temperature. Entering Scale (a) at 49.6, draw a line through the wet bulb temperature of entering air, 65.4 F, on Scale (b), and extend the line to Scale (c). From the intersection with Scale (c), pass horizontally to the 18,000 Btu ordinate. It can be seen that the intersection occurs on the air velocity line of 2500 lb per hr, showing that 2500 is the air velocity necessary to give the capacity desired.

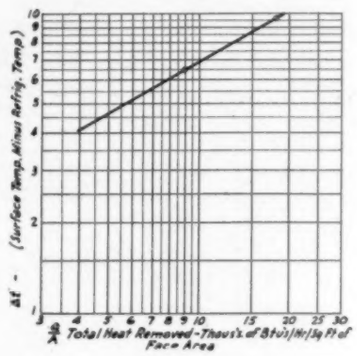


Fig. 5

To determine the latent heat removed, draw a line from 49.6 F on Scale (f) through the dewpoint temperature of the entering air, 54.6 F, on Scale (e), to intersect Scale (d). From the intersection, pass horizontally

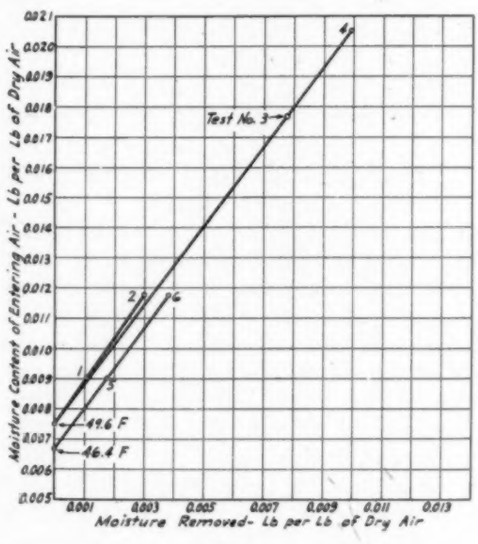


Fig. 6

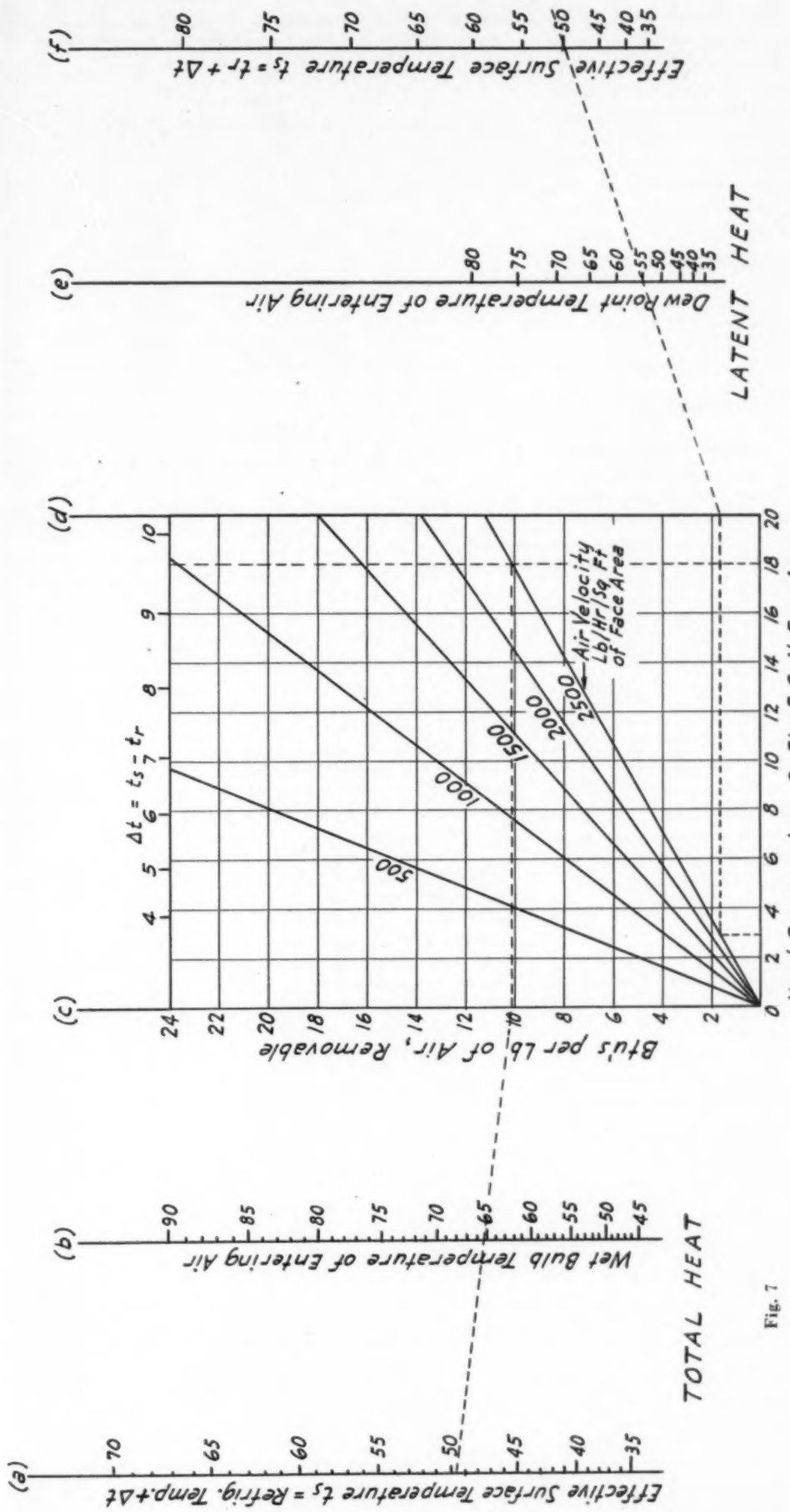

(f)
Effective Surface Temperature $t_s = t_r + \Delta t$
80 75 70 65 60 55 50 45 40 35
(e)
Dew Point Temperature of Entering Air
80 75 70 65 60 55 50 45 40 35
LATENT HEAT
(d)
$\Delta t = t_s - t_r$
Air Velocity Lb/Hr/Sq Ft of Face Area
2500 2000 1500 1000 500
Heat Removed per Sq Ft of Coil Face Area Thousands of Btu's per Hr (Total or Latent)
0 2 4 6 8 10 12 14 16 18 20
(c)
Btu's per Lb of Air, Removable
24 22 20 18 16 14 12 10 8 6 4 2
(b)
Wet Bulb Temperature of Entering Air
90 85 80 75 70 65 60 55 50 45
TOTAL HEAT
(a)
Effective Surface Temperature t_s = Refrig. Temp. + Δt
70 65 60 55 50 45 40 35

Fig. 7

to the 2500 line and then downward, reading 2900 Btu per hr per sq ft of face area.

In case it is desired to solve a problem in which the air velocity is known, with the total heat removed unknown, it is necessary to assume a value of Δt, and to check the answer to see if the assumption was correct. If not, then adjust Δt until a balanced condition is attained. This can usually be done quickly in three trials.

Construction of Fig. 7

The calculations for constructing Fig. 7 are as follows:

Scales (c) and (d) are identical, and represent $(h_1—h_s)$ or 1060 $(m_1—m_s)$ of Eqs. 5 and 6, namely, the removable heat per pound of air. The air velocity lines are drawn to perform the multiplication of Scale (c) times R times G, thus satisfying Equations 5 and 6, and showing Q/A on the abscissa.

Scale (a) is a uniform scale of total heat per lb of saturated air above a datum of 32 F and similar to scale (c), but it has the corresponding values of wet bulb temperature indicated, instead of Btu per lb, for convenience in using. Scale (b) is similar to scale (a), but of half the height. The distances between Scales (a) and (b), and between Scales (b) and (c) being the same, a line drawn through values on Scales (a) and (b) will give the difference between the values on Scale (c), which is of the same height as Scale (a). Thus the subtraction $(h_1—h_s)$ is performed.

The scale for Δt is drawn opposite the corresponding values of total

heat removed per sq ft, Q/A. The $\triangle t$ scale must not be used in connection with determinations of latent heat, because there is no functional relation between the two.

For latent heat removal, Scale (f) is drawn in units of lb of moisture per lb of dry air times 1060, except that the corresponding dewpoint figures are indicated for convenience sake. Scale (e) is similar to Scale (f), but of half the height. Scale (d) is similar to Scale (f), and both of these scales are equidistant from Scale (e). A line drawn through values on Scales (e) and (f) will show the difference between the values on Scale (d), which is the same as Scale (c). Thus, the calculation 1060 (m_1—m_2) of Eq. 6 is performed. The remainder of the equation, multiplication by R and G, is performed by the radial lines.

Limitations of the Method

For most finned coils, it is recommended that each depth of coil be tested separately, due to variations in R and $\triangle t$. Attempts by the author to find a relation between coils of various depths have not yet succeeded, but it appears that such a relation can be expressed as whole powers of the values of R of the first row of tubes. $\triangle t$ should be an average of the $\triangle t$'s of all rows.

Coils of various lengths should also be tested separately, because $\triangle t$ varies with the change in velocity of the refrigerant, to a slight extent.

The method of determining $\triangle t$ described cannot be applied to water-cooled coils.

Eq. 5 and Fig. 7 should not be used for determining coil performance when no moisture is being removed. Instead, Eq. 8 should be used.

For ratios of latent to total heat between approximately 0.08 and zero, a coil will usually remove more moisture than is indicated by Eq. 6. This is due to the fact that the theory of the method employs the *average* surface temperature. When the average is equal to the dewpoint of the entering air, there are parts of the surface that are below the dewpoint. These parts will condense a small, and usually negligible, amount of moisture.

Testing Schedule

Below is a recommended schedule of 6 tests, which, if perfectly executed, will provide all the data necessary for preparing the curves described. The author has found it desirable to use twice this number, however, to check results.

Test No.	$\frac{Q}{A}$	t_r	G	Relative Humidity of Entering Air
1	18,000	40°	2500	85%
2	18,000	40	2500	70
3	18,000	40	1000	40
4	18,000	40	1000	70
5	9,000	40	1000	35
6	9,000	40	1000	70

Let us assume that the above testing schedule has been followed, and that the results shown below have been obtained. Fig. 6 shows the data plotted, giving values of $\triangle t$ that are later plotted in Fig. 5, and values of R that are plotted in Fig. 2. The values for Fig. 2 are:

$R = 0.76$ when $G = 1000$
$R = 0.71$ when $G = 2500$

Substituting these values into Eq. 3 and solving the two simultaneous equations gives the formula for the curve of Fig. 2:

$$\log_{10}(1-R) = -\frac{2.29}{G^{0.189}} \qquad \text{Eq. 9}$$

Fig. 7 embodies the results in the final form for use.

EXAMPLE

Assumed Test Results

Entering Air Conditions

Test No.	Dry Bulb Temp.	Wet Bulb Temp.	Moisture Content Lb/Lb air m_1	Condensate Removed Lb/Lb of air m_1-m_2	$\triangle t$	t_s
1	84.5	65.4	0.0091	0.00114	9.6	49.6
2	72.0	65.4	0.0118	0.00305	9.6	49.6
3	100.7	80.2	0.01775	0.0078	9.6	49.6
4	88.1	80.2	0.0206	0.00995	9.6	49.6
5	84.1	65.3	0.0090	0.00175	6.4	46.4
6	71.8	65.3	0.01175	0.00384	6.4	46.4

Addendum I

Relation Between R and K

Most manufacturers of heating and cooling coils use the conventional coefficient of heat transfer K to rate the capacity of their coils. The disadvantage of this method lies in the fact that it is usually necessary to assume, in advance of the solution of a problem, the leaving air temperature in order that the log mean temperature difference may be obtained to substitute into the formula: $Q_s = K\ A\ a\ (M.T.D.)$

Since the leaving air temperature depends upon Q_s, it is necessary to cut and try several times to find the solution. Ratio R, on the other hand, gives an immediate solution by the use of Eq. 8. Furthermore, R offers the possibility of using a simple graphical chart which obviates the use of calculations.

It should be realized that most heating coils are rated with an *overall* K. This is justified by the fact that the heat transfer coefficient of condensing steam is approximately independent of steam velocity, and it can be shown that the use of surface temperature is superfluous, though perhaps it is more correct theoretically. In the case of hot water heating, however, where the internal surface coefficient of heat transfer is a function of water velocity, the use of an overall K for finned coils must be incorrect, and probably is very inaccurate. The use of R and of t_s is more accurate. (For heating or cooling by water, Fig. 5 cannot be used to obtain t_s).

To show that R is consistent with established practice, the relation of R to K, for surface coefficients, is developed below. The existence of such a relation is suggested by the fact that both are functions of air velocity.

Given the definitions:

$$K = \frac{Q_s}{A\ a\ (M.T.D.)} \qquad \text{Eq. 10}$$

$$M.T.D. = \frac{D_1 - D_2}{2.3 \log_{10}\frac{D_1}{D_2}} \qquad \text{Eq. 11}$$

$$D_1 = t_1 - t_s \qquad \text{Eq. 12}$$

$$D_2 = t_2 - t_s \qquad \text{Eq. 13}$$

Substituting Eqs. 12 and 13 into 11, and 11 into 10, we get:

$$K = \frac{Q_s\ 2.3 \log\left(\frac{t_1 - t_s}{t_2 - t_s}\right)}{Aa} \qquad \text{Eq. 14}$$

By definition:

$$Q_s = s\ A\ G\ (t_1 - t_2) \text{ or: } \frac{Q_s}{A} = s\ G\ (t_1 - t_2) \qquad \text{Eq. 15}$$

Substituting Eq. 15 into 14, and using the value: $s = 0.245$ as an average for moist air, we get:

$$K = 0.245\ G \times \frac{2.3}{a} \times \log\left(\frac{t_1 - t_s}{t_2 - t_s}\right)$$

Rearranging:

$$K = \frac{0.564\ G}{a} \log \frac{1}{\left(\frac{t_2 - t_s}{t_1 - t_s}\right)} = \frac{0.564\ G}{a} \log \frac{1}{\left(\frac{t_2 - t_s + t_1 - t_1}{t_1 - t_s}\right)}$$

$$K = \frac{0.564\ G}{a} \log \frac{1}{\left(\frac{t_1 - t_s}{t_1 - t_s}\right) - \left(\frac{t_1 - t_2}{t_1 - t_s}\right)}$$

$$K = \frac{0.564\ G}{a} \log_{10}\left(\frac{1}{1 - R}\right) \qquad \text{Eq. 16}$$

From this formula, K can be converted into R. For steam heating coils, Eq. 8 can be used, in which Q_s will be the total heat transferred and t_s will be the temperature of the steam. The data can be presented graphically, using a form similar to Fig. 7, but with the right hand portion and the Δt scale omitted. In place of Scale (a) it would be necessary to use a scale of entering air dry bulb temperatures, and in place of scale (b), a scale of steam temperatures or pressures.

Addendum II

Calculation of R from Sensible Heat Removed

Ratio R can be calculated also from test data values of sensible heat removed. Eqs. 10 and 16 can be set equal to each other as follows:

$$\frac{Q_s}{A\ a\ (M.T.D.)} = \frac{0.564\ G}{a} \log\left(\frac{1}{1 - R}\right) \qquad \text{Eq. 17}$$

Rearranging:

$$\log_{10}\left(\frac{1}{1 - R}\right) = \frac{Q_s}{0.564\ A\ G\ (M.T.D.)} \qquad \text{Eq. 18}$$

However, since the latent heat removed by a coil is usually less than the sensible heat, performance that is calculated from total heat minus sensible heat will often produce large errors in predictions of latent heat. For example: if the ratio of latent to total heat is 1 to 10, a 2 per cent error in sensible heat, when subtracted from total heat, will cause an error of 20 per cent in latent heat.

It is preferable, therefore, instead of using Eq. 18, for determining R, to use latent heat obtained from condensate actually collected during a test period of ½ to 1 hour. Eq. 18 should be used for checking purposes only.

Field Tests—

[*Concluded from page 664*]

Selecting the Shape of Structure

It may be of interest that during the preliminary stages of design, numerous shapes were considered, and the one that appeared to be second choice was a design in the form of a U-bend extending vertically toward the roof. In making the flexibility analyses for this proposed design, it was found that for the maximum combined stress to be within the allowable, the required height of the U-bend would be approximately 50 ft. This U-bend, then, would contain 286 linear feet of pipe as compared to 236 linear feet for the cross-over of Fig. 1.

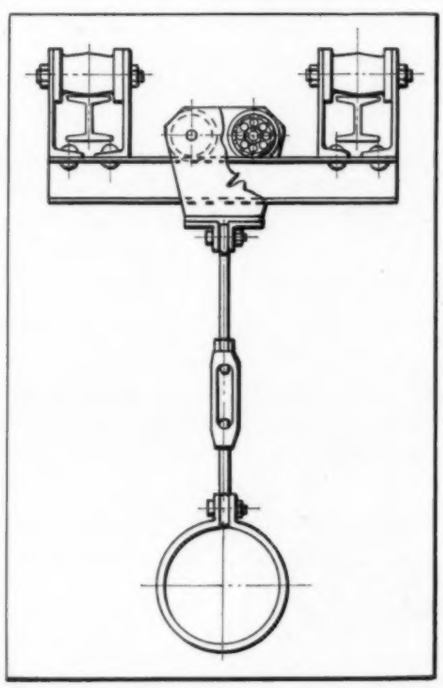


Fig. 6—Type of hanger used, the multiple roller feature being original in design

It was also found by investigation that the pressure drop in the U-bend would be greater.

The question of properly supporting the line was of major importance, particularly since the movement in the vertical direction due to the elongation of the lengths of pipe would vary from 3½ in. at the top of the vertical legs to 10½ in. at the mid-point of the top horizontal run of pipe. It would have then been necessary, in order properly to absorb this large vertical movement, to install specially designed and consequently expensive compensating hangers; this type of hanger would have had to allow the line to travel through the complete range of cold to the hot position with a very small drop in load. Indications are that the cost of supporting this proposed U-bend would have been about three times that of supporting the present installation.

In general, the advantages the present design has over a U-bend design are: (1) A large reduction in the cost of supporting the line; (2) smaller amount of linear feet of pipe with fewer joints; (3) A more acceptable layout from the appearance standpoint.

Concluding Remarks

The problem discussed and illustrated clearly indicates the necessity of properly analyzing the change of shape which a pipe line undergoes in traveling from the cold to the hot position. It shows the practicability of applying the grapho-analytical method to this phase of design, and also that the use of graphs, wherever possible, offers the greatest ease in solution.

A comparison of the theoretical and actual movements tends to indicate that where a painstaking and proper analysis of the movement of a pipe line in operation has been made, the structure will behave about as expected. This problem also demonstrates the extent to which an analysis of this nature can help in deciding the question of how properly to support the structure.

In conclusion it can be said that in such cases the results of a flexibility analysis fully justify the amount of time and study devoted to it.

Strength and Design of Covers and Flanges for Pressure Vessels and Piping

[Part 2]

By T. McLean Jasper*, H. Gregersen*, and A. M. Zoellner*

THE construction of a vessel or pipe line for high pressure service involves a balance in the design at every point so that the safety of such equipment can be assured.

Previous investigations have established the necessity for and the required amount of reinforcement for openings in vessel walls and for the proper shapes of heads of vessels. The present investigation aims to go into the question of covers and flanges of openings. Part 1, published last month, was concerned with covers and ring flanges.

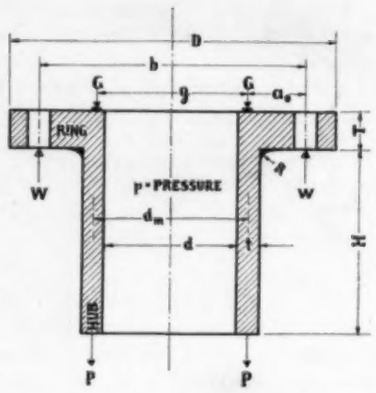


Fig. 7—Longitudinal section of hubbed flange with the forces acting on it

3. HUBBED FLANGES

The longitudinal section of a hubbed flange with the forces acting on it is shown in Fig. 7.

It has been assumed that the gasket load is acting on a circle having a diameter g equal to the mean diameter d_m of the hub. Thus the load P due to the internal pressure p is

$$P = \frac{\pi}{4} d_m^2 p \quad \ldots\ldots [10]$$

Approximately the total magnitude of P is acting as a pull producing tension in the junction between the ring and the hub. The equation of equilibrium is:

$$W = G + P \quad \ldots\ldots [11]$$

in which G is the gasket load when the pressure p is acting, and W is the total bolt load.

Under the action of the forces W, P, and G the flange is subjected to an external bending moment M the magnitude of which will be:

$$M = Wa_o \quad \ldots\ldots [12]$$

This is based on the assumption that the gasket load is acting on a circle having a diameter g equal to the mean diameter d_m of the hub. In cases where the gasket is located close to the bolt circle the value of the external moment should be calculated as will be described in Appendix 4.

The essential stresses produced by the external bending moment M are the bending stresses in the junction between ring and hub and the tangential stresses in the ring. Theoretical investigations show that for all ordinary dimensions the bending stress in the junction between ring and hub will be by far the largest. Thus the maximum stress in a hubbed flange will generally occur at the junction between ring and hub and equals the sum of the maximum bending stress produced by the external moment M and the tensile stress produced by the pressure load P. The tensile stress in the junction is approximately:

$$S = \frac{P}{\pi d_m t} \quad \ldots\ldots [13]$$

For the maximum bending stress in the junction between ring and hub the following two formulas have been developed.

Formulas by Holmberg-Axelson[6]†:

$$S = \frac{6M_o}{t^2} \quad \ldots\ldots [14]$$

where M_0 is the bending moment per unit length of circumference in the junction between ring and hub and can be calculated from the following formula:

$$M_o = \frac{(AT^2 + 1.831t\sqrt{d_m t})Q_o + BTW - 0.4375t\left(d_m t - 0.572A\frac{T^2}{t}\right)p}{1.5AT - 3.35t} \quad \ldots\ldots [15]$$

where Q_0 is the shearing force per unit length of circumference in the junction between ring and hub and can be calculated from the following formula:

$$Q_o = \frac{\left(d_m t - 0.572A\frac{T^2}{t}\right)(0.874t + 0.214B\sqrt{d_m t})p - 2B(T + 0.545\sqrt{d_m t})W}{1.831t\sqrt{d_m t} + A\left[T^2\left(2 + 0.1218\frac{\sqrt{d_m t}}{t}\right) + 1.64T\sqrt{d_m t} + 0.895d_m t\right]} \quad \ldots\ldots [16]$$

The values of A and B in Formulas 15 and 16 can be calculated from the following formulas:

*Research Engineer, A. O. Smith Corp., Milwaukee, Wis.

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This paper was presented at the annual meeting of the *American Society of Mechanical Engineers*, December, 1934, New York, N. Y., but has not heretofore been available in published form.

† See Part 1, November issue, for references.

List of Symbols Used

W—Total bolt load
G—Gasket load
D—Outside diameter of cover, ring, or flange
T—Thickness of hub in a hubbed flange
S—Stress
S_r—Modulus of rupture
$M=Wa$—External moment applied or assumed in design
M_o—moment per unit length of circumference
Q—Force
Q_o—Shearing force per unit length of circumference
M_{test}—Moment applied in test samples at failure
S_{test}—Stress obtained in test samples at failure
b—Bolt circle diameter
g—Gasket diameter
d—Inside diameter of flange or ring opening
a—Distance between gasket and bolt circle
a_o—Distance from bolt circle to center of hub thickness in a hubbed flange
d_m—Mean diameter of hub in a hubbed flange
t—Thickness of hub in a hubbed flange
μ—Poisson's ratio

$$A=\left(\frac{5D^2+3d_m^2}{D^2-d_m^2}\right)\frac{t^3}{T^3} \quad \text{.....[17]}$$

$$B=\frac{3.58}{D^2-d_m^2}\left[0.767D^2\log_{10}\frac{b}{d_m}+0.1(b^2-d_m^2)\right]\frac{t^3}{T^3} \quad \text{.....[18]}$$

In the development of the formulas, Poisson's ratio[2] has been taken $\mu = 0.25$. The formulas are based on the general plate theory and the theory of bending of bars on elastic foundation. In the development it has been assumed that the gasket load is acting on a gasket load circle with a diameter equal to the mean diameter of the hub for which conditions the formulas are generally valid since no other assumptions have been made. From the formulas it can be seen that the bending stress in the joint is expressed as a function of the internal pressure. The internal pressure has the tendency to deform the flange so as to change the maximum bending stress. However, numerical examples[5] have shown that this change is of minor importance and the above formulas can be somewhat simplified by introducing $p = 0$.

Formula by Timoshenko[4]:

$$S=\frac{6M_o}{t^2} \quad \text{.....[19]}$$

where M_0 is the bending moment per unit length of circumference in the junction between ring and hub and can be calculated from the following formula:

$$M_o=\frac{M}{\pi d\left[1+\frac{\beta}{2}T+\frac{\log_e(D/d)}{\beta dt^2}T^3\right]} \quad \text{.....[20]}$$

where:

$$\beta=\sqrt[4]{\frac{12(1-\mu^2)}{t^3d^2}} \quad \text{.....[21]}$$

Assuming Poisson's ratio[2] $\mu = 0.25$ and substituting for the natural logarithm the common logarithm[3] and combining Formulas 19, 20, and 21 results in:

$$S=\frac{1.91M}{td\left[t+\frac{0.915t}{\sqrt{td}}T+\frac{1.257\log_{10}(D/d)}{t\sqrt{td}}T^3\right]} \quad \text{.....[22]}$$

Formula 22 is based on the theory of deformation symmetrical about axes[4] and the theory of bending of bars on elastic foundation. In its development accuracy has been somewhat sacrificed for the sake of simplicity.

Formulas 14-22 for the strength of hubbed flanges have the disadvantage of not being practically solvable for flange thickness but for stress only. Thus repeated calculations for assumed thicknesses are necessary in order to arrive at the thickness corresponding to the allowable stress.

Fillet Coefficients

It is of importance to state that Holmberg-Axelson's and Timoshenko's formulas for hubbed flanges do not take into consideration the influence of a fillet at the junction between ring and hub. In the case of a sharp corner at this junction ($R = 0$ in Fig. 7) a stress concentration will take place which is not provided for in the above formulas. Thus the application of Holmberg-Axelson's and Timoshenko's formulas for hubbed flanges is only correct for flanges provided with a fillet large enough to avoid stress concentration. How large this fillet must be in the various cases in order to serve its purpose depends largely on the brittleness of the flange material.

If the size of a fillet is increased above the size required to avoid stress concentration the strength of the flange increases. Since a large fillet can be produced with a comparatively small amount of material it is possible to save material by reducing the flange thickness and to increase the strength of the flange by employing a generous fillet.

The problem of determining in an exact manner the influence of a fillet on the strength of a hubbed flange is extremely difficult. In the following, an approximate—and for design purposes sufficiently accurate—method of determining the influence of circular fillets on the strength of hubbed flanges is given.

Theoretical investigations[6] have established that the bending moment in the hub decreases rapidly with increased distance from the junction between ring and hub. Thus the effect of a fillet in the junction between ring and hub will be to remove the location of the dangerous section from the junction between ring and hub to a certain location along the hub where the magnitude of the bending moment causing fracture has a smaller value. Based on this principle the following formula for a fillet coefficient (see Appendix 3) has been developed:

$$\phi=e^{-(\beta nR)}\cos(\beta nR) \quad \text{.....[23]}$$

where: $\beta=\sqrt[4]{\frac{12(1-\mu^2)}{t^3d^2}}$

ϕ = Fillet coefficient to be used in combination with any appropriate formula for hubbed flanges.
R = Fillet radius.
n = Factor based on test results.

From the test results with hubbed flanges provided with various fillet radii the factor was found to be $n = 0.6$. Introducing this value of n in Equation 23 and assuming Poisson's ratio[2] $\mu = 0.25$, Equation 23 can be written:

$$\phi=e^{-\left(1.1\frac{R}{\sqrt{td}}\right)}\cos\left(1.1\frac{R}{\sqrt{td}}\right) \quad \text{.....[23a]}$$

In order to facilitate the practical application of the fillet coefficient Ø Equation 23a has been numerically evaluated within the practical range. Corresponding values of Ø and $R/\sqrt{td}$ are given in Table 1, from which the curve shown in Fig. 8 has been plotted for the purpose of eliminating interpolations.

Table 1

$\frac{R}{\sqrt{td}}$	Ø
0.00	1.000
0.05	0.945
0.10	0.890
0.15	0.837
0.20	0.783
0.25	0.731
0.30	0.680
0.35	0.632
0.40	0.583
0.45	0.537
0.50	0.492
0.55	0.448
0.60	0.408
0.65	0.368
0.70	0.333

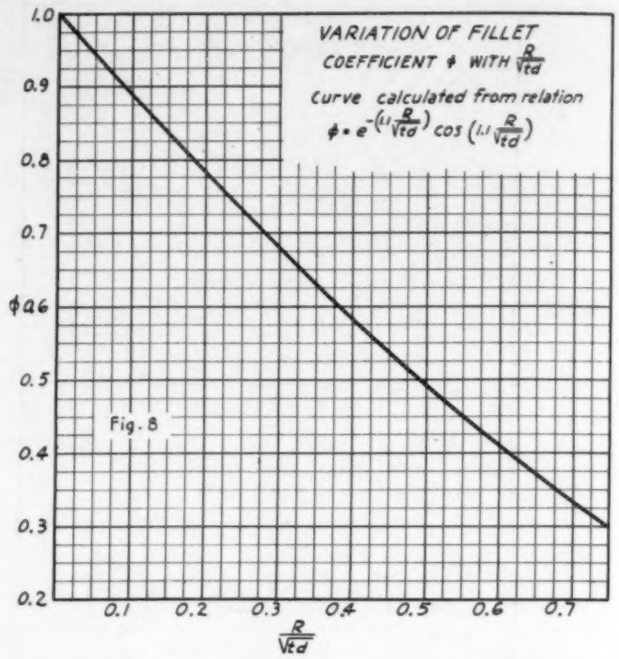
Introducing the fillet coefficient in the formulas by Holmberg-Axelson and Timoshenko, Formulas 14 and 19 will take the following form:

$$S = \text{Ø}\,\frac{6M_o}{t^2} \qquad [24]$$

and Formula 22 by Timoshenko:

$$S = \text{Ø}\,\frac{1.91M}{td\left[t+\frac{0.915t}{\sqrt{td}}T+\frac{1.257\log_{10}(D/d)}{t\sqrt{td}}T^3\right]} \qquad [25]$$

From Fig. 8 it can readily be seen that a fillet is more beneficial to a flange with thin hub than to a flange with thick hub. Since the size of a fillet can not be increased in proportion to the other dimensions of a flange because of the comparatively small flange width the application of fillets of practical dimensions will be considerably more beneficial to small flanges than to large flanges.



The derivation of Equation 23 will be given in Appendix 3, with more detailed information about the effect of fillets.

[To be continued]

"Old Ironsides" Winter Air Conditioned

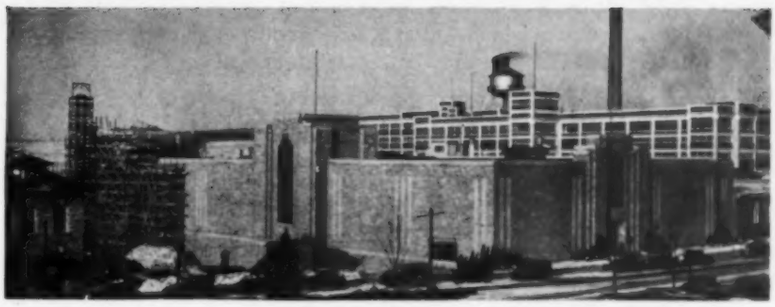
"OLD IRONSIDES," the historic 54 gun frigate christened the "Constitution" when she was launched at Boston in 1797, has been winter air conditioned. This, the oldest commissioned ship in the U. S. Navy, restored for the fourth time in 1927 and for the past year or more berthed at the Charlestown, Mass., navy yard, is now safeguarded against shrinkage or checking of her timbers.

Wooden vessels, when not in active service, are liable to dry rot and decay from lack of the moisture they get at sea and from the regular washing down by the crew. During the winter the gun and berth decks of "Old Ironsides" are heated for the comfort of visitors. Installation of a simple heating system would reduce the air's relative humidity and tend to dry out excessively the timbers, which would result in abnormal shrinkage and checkage. There is sufficient moisture in the air during summer to keep the ship in condition during those months.

The conditioning system is installed on the gun deck with ducts leading to the berth deck below. The ducts extend from the spray chamber along the port side, above the guns, on brackets suspended from the deck above. A similar duct system extends along the port side of the berth deck, next below, connected with the main system by drops through the main and after hatches. This line has branches across to the starboard side and back to the officers' quarters in the stern. Similarly the gun deck line has branches across deck to starboard, with end grilles. Grilles are spaced about 25 ft apart, eight on the gun deck and nine on the berth deck. Humidity is maintained at 30 to 35 per cent, with 70 F dry bulb. Unit heaters supplement this system at outdoor temperatures below 20 F.

All ducts were put together with bolts and nuts and brackets fastened with screws, the joints butted with felt and closed with water glass. The entire installation can be dismantled quickly and stowed for the summer. Steam is supplied from the yard's central heating plant by pipes brought over the side.

"Old Ironsides"



Air Conditioning Windowless Office Building

Several installations made during recent months are concrete evidence of the growing recognition of the advantages of air conditioning office spaces . . . Two interesting jobs are described on this and the next page. One is the Hershey Chocolate Corporation's windowless building, the design of which incorporates a number of unusual features . . . The other is the office building of the Dewey & Almy Chemical Company, where cold well water used in the process is first bypassed through the cooling coils.

By **A. Bowman Snavely***

OBJECT of the windowless design employed for the Hershey Chocolate Corporation's office building at Hershey, Pa., is to promote employee efficiency and reduce operating charges. Cost of construction was less than that of a conventional type of building, and proper insulation and elimination of heat leakage through windows is expected to result in a 25 per cent decrease in cost of operating the air conditioning system; elimination of noise and infiltration of dust and dirt, freedom from drafts during winter months, and increasing the general efficiency and personal comfort of employees and executives are among the features that recommended the design. Our experience after several months occupancy has been quite satisfactory.

Total floor area of Hershey's building is 205,260 sq ft, of which 62,816 sq ft is office space, 48,471 sq ft is for the printing department, and some 33,000 sq ft is devoted to locker rooms; remainder is for equipment and miscellaneous purposes. The office portion contains 22 private offices and five general office areas.

The building is 151 ft wide and 350 ft long, having a basement and three stories above ground. The walls are of native limestone trimmed with Indiana limestone, and hollow tile with a 3 in. air space. The roof is unique; it is a dead level concrete deck where at all times there will be about 2½ in. of water to act to some extent as an insulator.

Two separate air conditioning systems each incorporate a 135 ton water cooling system and air washers; one supplies conditioned air to the general offices in the front of the building while the other handles the label and chocolate package printing department, paper storage rooms, etc., in the rear. Refrigeration equipment for each of the systems is practically identical, consisting of a 14 by 10 in. double cylinder "Freon" compressor, direct connected to a 125 hp synchronous motor, operating in connection with a 16 ft by 38 in. shell and tube condenser. Compressors, condensers, and pumping equipment are in the basement, and from each of the water coolers, chilled water is pumped to the air washers, for the various zones.

Thus, main floor offices are served by one washer, and second floor offices by another. Each is designed to maintain a summer condition predicated on outdoor temperature variations, to avoid shock on entering or leaving. This is done by employing differential thermostats set so that when the outside temperature is 70 F, the indoor temperature will be 72 F, and for each 3 F increase in outdoor temperature the indoor temperature will increase 1 F.

The main floor air washer is in the basement, and conditioned air is supplied to ducts furred in above the hallways. Air is returned through grilles in the lower part of the office doors into the hallways from which it is drawn, with some outside air, back to the washer. The second floor is similarly conditioned by a washer in a pent house on the roof from which insulated supply ducts running across the roof distribute the air to plaques in the second floor ceiling. Air is returned to the washer from grilles at the floor line at one end of the building.

A minimum of 15 cfm of outside air per person is introduced, with a complete change of air every eight minutes.

The front and rear sections of the building (housing the executive offices and printing departments, respectively) are isolated from each other to prevent transmission of vibration from the printing rooms into the offices. Air velocity in the ducts was another consideration in securing a low sound level in the offices, the maximum velocity in those serving the offices being 1,800 fpm, and in the others, 2,000 fpm.

The system for the printing department is similar in compressor capacity (135 tons), but has in addition a well water air cooling system.

The printing, cutting and locker rooms are cooled by 830 gpm of 55 F deep well water pumped to an air washer. Storage and lunch rooms are cooled by a washer served by the mechanical refrigeration unit.

The building is heated by extended surface steam coils, reheaters being installed with the washers to reheat recirculated air, and preheaters being used to bring up to temperature all outside air introduced. Air control dampers are pneumatically operated, and arranged so that the change-over from summer to winter operation can be made by means of a single hand switch which

*Chief Engineer, Hershey Chocolate Corp., Hershey, Pa.

automatically adjusts the position of the various dampers. There is also a switch which automatically controls the position of the various dampers. Total circulation of the combined systems is 193,000 cfm.

A unique feature is the "electric weather man" which tells the occupants what weather to expect when they leave the building. This consists of a small panel placed near the electric clock in each office, with three colored lights. Seven different combinations of the lights indicate the weather.

Deep Well Water Does Double Job; Cools Offices, Then Goes to Process

By W. H. Wetherell*

THE air conditioning system for the office building of the Dewey & Almy Chemical Co., Cambridge, Mass., incorporates a feature which is interesting and which is indicative of how an air conditioning system must be individually engineered to meet the requirements of the particular case for most economical results.

Deep well water—180 gpm at a temperature of 52 F—is available, as it is used in the manufacturing process. The air conditioning system was designed to use 90 gpm of this water at 54 F, the two degrees being allowed for heat picked up between the well and the conditioning unit. As the total heat load of the building is about 270,000 Btu per hr, there is a 6 F rise in temperature of the water through the conditioner, or a 3 F rise in the total of 180 gpm. The 90 gpm used for conditioning is bypassed through the cooling coils and rejoins the main stream to the process. Coils were used instead of a washer so that the water to be used later in the manufacturing process would not be contaminated; the plenum chamber was constructed so that if at any time it is found desirable to substitute direct expansion coils for the water coils, this can be done. A requirement was low pressure drop through the coils, and the design employed results in a drop of but 9 lb per sq in., approximately.

A zone control system is used to take care of load variations due to sun effect—practically the only variable. For heating, the design provided for a tempering coil in the plenum chamber controlled so as to maintain a constant temperature of air delivered to zones of about 65 F. In each of the four zones a booster coil controlled by a thermostat in that zone regulates the temperature of that zone. In the east zones, to prevent overheating in the southeast rooms, a volume control damper controlled by a room thermostat is installed in each room. To prevent underheating in the northeast rooms, direct radiation automatically controlled is installed.

A motor operated damper in the outside air intake closes the outside air supply whenever the fan shuts down. Manual operation of this motor for varying outside air quantities is provided for.

An additional thermostat with an 8 deg differential operating directly on the fan circuit as well as the controls permits the fan to cycle as heat is needed during night operation. A manual switch provides for changing from day to night operation.

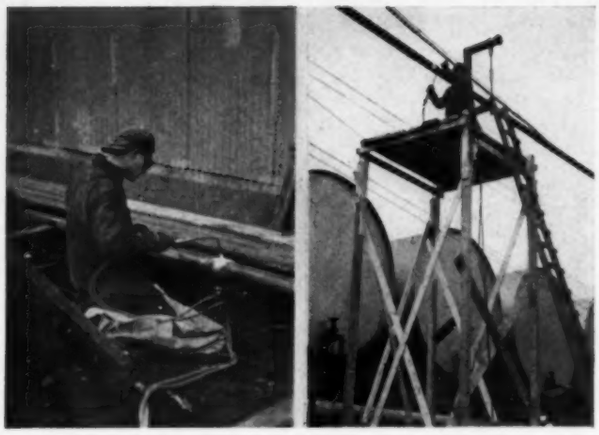
In general, the zone control for cooling operates as for heating, except that zone thermostats operate zone modulating dampers to vary the amount of air according to the zone load; these dampers are set at a low limit so that there will always be a minimum amount of air supplied to each zone. If this minimum air quantity more than carries the load, thermostats located near the return grilles on each floor operate to modulate the amount of cooling supplied by the central chamber, by cutting off coils in successive banks until equilibrium is reached.

The southeast rooms are further controlled for summer operation by reversing the action of the volume damper provided in these rooms for winter control.

For control on mild humid days, a high limit humidistat is provided which calls for dehumidification whenever 50 per cent relative humidity is exceeded in the occupied zone. To prevent this control creating uncomfortably low dry bulb temperature, a low limit thermostat operates the steam valve for reheating.

Dewey & Almy's conditioned office building.

*Chief Engineer, General Heat & Appliance Co., Boston, Mass.



Left—Operator making multi-layer weld on 4 in. extra heavy pipe.
Right—Operator making position weld on 4 in. extra heavy pipe

Multi-Layer Oxy-Acetylene Pipe Welding

[Part 2]

By Arthur N. Kugler*

MULTI-LAYER oxy-acetylene welding[1] is used on heavy wall pipe such as is encountered on power piping installations and other constructions where stresses are high, necessitating the use of a larger cross-sectional area of steel. The *American Standards Association* code for pressure piping, issued about a year ago, requires welding of the highest order to fulfill its specifications. Based on field experience covering many welders, we can safely say that multi-layer oxy-acetylene welding will enable any reasonably competent operator to pass these code tests without difficulty.

For the purposes of this discussion we shall consider two power piping installations on which the data are complete. One involved piping operating at 625 lb per sq in. and 750 F total temperature. The other, a smaller plant, operates at 275 lb per sq in. and 545 F. All design and welding was carried on in accordance with the requirements of the *A. S. A.* code. The piping on the larger installation was stress relieved, while on the smaller one no heat treatment was employed. Seamless tubing was used on both systems for the high pressure piping. On the 625 lb system the heaviest pipe wall used was $\frac{9}{16}$ in., while on the 275 lb system ½ in. was the greatest wall thickness.

Multi-layer welding comprising two complete layers made in two revolutions of the pipe was used on all this work. The filler material was standard welding rods applied with the backhand technique. The first pass was made to a depth of ½ to ⅓ the pipe wall thickness, its surface being maintained flat to concave. Field experience closely checks laboratory on this point. If the first and intermittent layers are convex the speed of welding is greatly retarded on the following layers. In addition, the weld on test will show considerable evidence of porosity, cold shuts and slag inclusions at the two "valleys" created by the convexity. The second layer was welded to the first, building up the weld to the required reinforcement and width.

Nine welding operators were qualified to weld on these systems. Of this number, five worked in piping fabricators' shops where nearly all work was on horizontal pipe rolling welds; four were employed in field erection crews. Since much of the piping was shop fabricated, practically all of the field welds were made in position. In every instance the operators were required to make the position welds. On the 625 psi system the test welds were made on 14 in. O.D. seamless tubing $\frac{9}{16}$ in. thick. On the 275 psi system test welds were on 8½ in. O.D. seamless pipe ½ in. thick. Rolling test welds were omitted, since most of this work had to be position welded. Further, experience indicates that an operator who can weld in position is capable of making the roll welds, since the latter are admittedly the easier.

In Table 1 are tabulated the results of the reduced section tensile tests. In every instance but one the welds equaled the strength of the pipe material. These results are to be expected with an alloy rod in the hands of a competent operator. The one coupon failing in the weld broke at an ultimate tensile strength greater than 90 per cent of the strength of the pipe material; this is permissible according to the code. Specimens with the following numbers or letters (to the left of the period) 2, 4, 8, 5 and *Q* represent tests for welding on the 625 psi, 750 F piping. The remaining coupons represent the lower pressure system.

Table 2 represents the free bend test results for the same operators. Since these are qualification tests, all results are in excess of the minimum specified. However, the figures indicate clearly that the average operator can produce these results.

The free bend test gives an indication of the ductility of the weld metal, which in turn is a measure of its ability to withstand shocks. This property of the weld metal on heavy wall pipe is of vital importance. These test results are, therefore, important in that they demonstrate that this method of welding insures adequate weld ductility.

Of the 18 nick break test coupons (tabulated in the original paper—ED.) only three showed evidence of defects and these defects were of a minor nature.

The reverse bend test results shown in Table 3 indicate the value of multi-layer welding in securing fusion through to the inner wall of the pipe. This test calls for bending of the test bars through 90 deg, at which angle

[1]Part 1, published in HEATING, PIPING AND AIR CONDITIONING, November, 1936, pp. 613-617, describes this process.

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From a paper presented at the annual meeting of the *American Welding Society*, Cleveland, Ohio, October, 1936. Complete paper published in the October, 1936, issue of the *Journal* of the *A. W. S.*

Table 1—Tensile Tests

Specimen No.	Specimen Dimensions: Thickness In.	Width In.	Area Sq In.	Total Load—Kips: Yield Point	Ultimate	Unit Stress—Kips/Sq In.: Yield Point	Ultimate	Break[a]
2.1	0.553	1.813	1.003	35.15	52.67	35.04	52.51	O.W.
2.3	0.490	1.812	0.8878	32.35	47.03	36.44	52.97	At edge of weld
4.1	0.551	1.816	1.001	35.82	52.93	35.78	52.88	O.W.
4.3	0.565	1.817	1.027	36.70	53.75	35.74	52.34	O.W.
8.1	0.565	1.817	1.0274	36.10	54.03	35.15	52.60	O.W.
8.3	0.504	1.814	0.913	32.40	48.00	35.44	52.50	O.W.
5.1	0.549	1.815	0.993	....	52.07	....	52.44	O.W.
5.3	0.591	1.800	1.070	....	54.41	....	50.85	I.W.—90%
Q.1	0.553	1.813	1.003	....	54.43	....	54.30	Edge of weld
Q.3	0.547	1.813	0.992	....	52.87	....	53.30	O.W.
V.2	0.440	1.563	0.687	....	33.00	....	48.00	O.W.
V.4	0.440	1.563	0.687	....	32.80	....	47.70	O.W.
S.1	0.438	1.400	0.613	....	38.70	....	63.10	O.W.
S.2	0.438	1.400	0.613	....	38.50	....	62.80	O.W.
A.2	0.440	1.484	0.653	....	30.40	....	46.68	O.W.
A.4	0.440	1.563	0.687	....	32.80	....	47.70	O.W.
M.2	0.440	1.484	0.653	....	30.50	....	46.70	O.W.
M.4	0.440	1.359	0.598	....	29.00	....	48.50	O.W.

[a]O.W. = Outside weld. I.W. = Inside weld.

they shall not break apart. It should be noted that every one of these test pieces was bent to 90 deg without any evidence of cracks.

These data are not hand-picked results but tabulations from the nine actual qualification test reports on file on these two projects.

Data are not available at the present time to tabulate the material requirements and time for welding each size and weight of pipe. However, from field experience it appears that a multi-layer weld will require from 75-85 per cent of the time for an equivalent single-layer weld. Obviously the oxygen and acetylene consumptions will be reduced in about the same proportion, while the amount of welding rods will remain about the same.

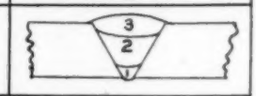
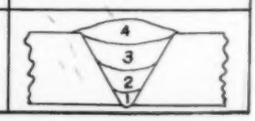
Table 2—Free Bend Ductilities

Spec. No.	Gage Length, In.: Before Bending	After Bending	Difference: In.	%
2.2	0.74	0.87	0.13	17.6
2.4	0.83	0.96	0.13	15.6
4.2	0.87	1.02	0.15	17.2
4.4	0.79	0.94	0.15	19.0
8.2	0.81	0.97	0.16	19.8
8.4	0.81	0.94	0.13	16.1
5.2	0.77	0.93	0.16	20.7
5.4	0.82	0.95	0.13	15.8
Q.2	0.805	0.970	0.165	20.5
Q.4	0.815	0.980	0.160	20.2
V.2	0.424	0.490	0.066	15.7
V.4	0.482	0.560	0.078	16.1
S.5	0.655	0.760	0.105	16.0
S.6	0.655	0.840	0.185	28.2
A.2	0.620	0.780	0.170	27.4
A.4	0.510	0.600	0.090	17.7
M.2	0.462	0.545	0.83	17.9
M.4	0.399	0.460	0.61	15.2
			Average	18.7

Table 3—Reverse Bend Test Results

Spec. No.	Final Angle of Bend	Fusion	Remarks
2.6	150°	Good	No failure
2.8	150°	Good	No failure at 90°—slight crack at edge at 150°
4.6	170°	Good	No failure
4.8	170°	Good	No cracks at 90°—slight crack at 170°
8.6	180°	Good	No failure at 90°—slight crack at 180°
8.8	150°	Good	No failure
5.6	180°	Good	No failure
5.8	180°	Good	No failure at 90°—slight crack at 180°
U.3	160°	Good	No failure
V.3	180°	Good	No failure at 90°—slight crack at 180°
S.7	160°	Good	No failure
S.8	160°	Good	No failure
A.3	180°	Good	No failure
M.3	180°	Good	No failure

Table 4—Recommended Procedure for Various Pipe Wall Thicknesses

Range of Pipe Wall Thickness	Number of Layers	Method of Depositing	Cross Section of Weld
3/8" to 5/8"	2	Two complete passes	
5/8" to 7/8"	3	Three complete passes; or layers 1 & 2 in one pass; layer 3 in one pass.	
7/8" to 1 1/8"	4	Four complete passes; or layers 1 & 2 in one pass; layers 3 & 4 in two passes.	

The recommended procedures for various ranges of pipe wall thickness are given in Table 4. Of course these recommendations are subject to modification, particularly where the ranges overlap.

The outstanding merit of multi-layer welding is its ability to produce welds of high quality on heavy wall pipe capable of withstanding severe stresses. This quality is readily obtained by any competent welding operator, since there is nothing radically new in the method.

By making the weld in layers, the operator can devote his attention to the peculiar difficulties at each zone. On the first layer he can secure proper fusion to the bottom of the vee without protrusions inside the pipe, since his puddle is relatively small. On the subsequent layers he can watch his fusion to the pipe walls and the previous layer without worrying about "breaking through." On the final layer the smaller puddle permits him to secure proper fusion at the upper corners of the vee. The annealing effect of the layers deposited by this method improves the ductility and the grain structure as indicated by the free bend and nick break tests.

Based on data from the laboratory and the field, we recommend multi-layer welding on all pipe above about 3/8 in. wall thickness. While power piping is probably the largest field for this class of piping, heavy wall pipe is also used for river crossings on transmission pipe lines, for hydraulic lines in mills and many other places.

Heating · Piping
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American Society of Heating and Ventilating Engineers JOURNAL SECTION

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Pittsburgh Experiment Station of the U. S. Bureau of Mines where the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS is located

Cooling Requirements for Summer Comfort Air Conditioning

By F. C. Houghten*, Pittsburgh, Pa., F. E. Giesecke**, College Station, Tex., Cyril Tasker†, Toronto, (*MEMBERS*), and Carl Gutberlet††, Pittsburgh, Pa., (*NON-MEMBER*)

IN the Spring of 1935 the Research Laboratory of the American Society of Heating and Ventilating Engineers was asked to make a study of the cooling requirements for summer comfort air conditioning. As a result of a brief study made in Pittsburgh during the summer of that year, a report[1] was presented to the 1936 Annual Meeting of the Society, indicating that the effective temperature scale was the best index of the relative feeling of warmth experienced by persons in summer air conditioned space. An effective temperature in the neighborhood of 73 deg was indicated as desirable in Pittsburgh under such conditions, rather than the 66 deg effective temperature generally accepted for winter heating and air conditioning. This study also gave information on the cold shock experienced upon entering a cooled space

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[1]Comfort Standards for Summer Air Conditioning, by F. C. Houghten and Carl Gutberlet. A. S. H. V. E. JOURNAL SECTION (*Heating, Piping and Air Conditioning*) November, 1935, p. 543.

For presentation at the 43rd Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, St. Louis, Mo., January, 1937.

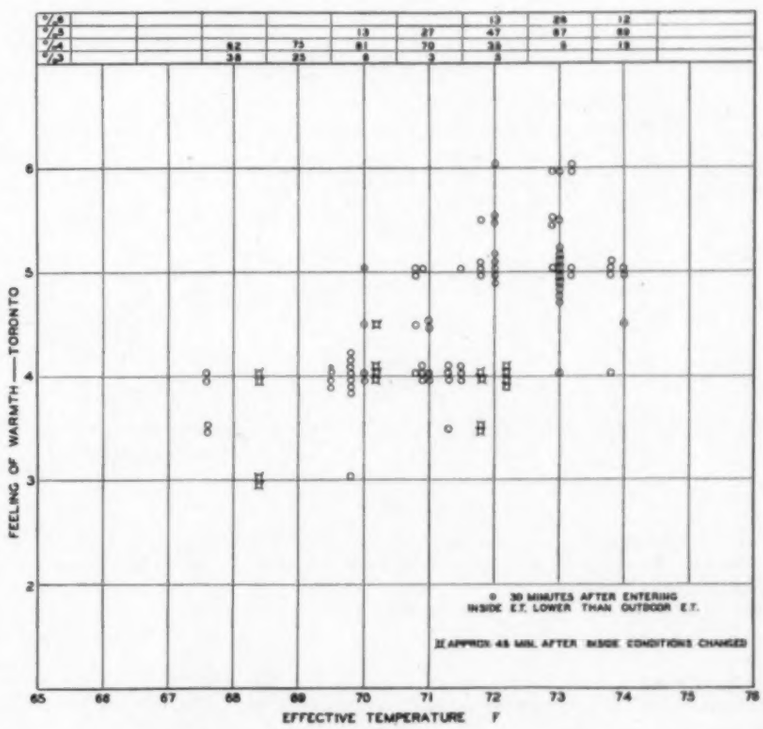


Fig. 1—Relation between effective temperature and feeling of warmth in Toronto on days when outside temperature was warmer than conditioned test room. Percentage of each numerical index of comfort is given in upper part of chart

and the time required under different atmospheric conditions, for establishing comfort and for the disappearance of sensible perspiration.

The brief period available for the study, together with the small number of subjects and their age limitations, affected adversely the conclusiveness of the study, and the Technical Advisory Committee on Comfort Requirements for Summer Cooling, W. L. Fleisher, *Chairman*, A. E. Beals, F. R. Bichowsky, Thomas Chester, F. E. Giesecke, Elliott Harrington, Dr. E. V. Hill, R. E. Keyes, Cyril Tasker, C. P. Yaglou, agreed that the study should be continued. The continued study was planned so as to give added information on the following points:

1. Desirable atmospheric conditions as regards temperature and humidity in still air for comfort in summer air conditioning, together with any variation in these requirements for different geographical regions having different weather conditions.
2. Allowable variations in the relative humidity of the air with optimum conditions of effective temperature, and any variation in the time required for the disappearance of sensible perspiration with variations in the moisture content of the air.
3. Variation in the required effective temperature for comfort depending upon the age, sex and general health conditions of the persons involved.
4. The effect of the amount of clothing worn, particularly the effect of coats worn by men, on the desired effective temperature.
5. The effect of air velocities, above those usually used in air conditioning, on the cooling requirements.
6. The characteristics and seriousness of the cold shock felt upon entering a cooled space in the summer, together with the duration of the shock and the subsequent physiological reactions or sensations up to the time when complete comfort is established.
7. The physiological reactions and sensations of a person leaving a cooled space and re-entering the hot outside, and the duration of these reactions.

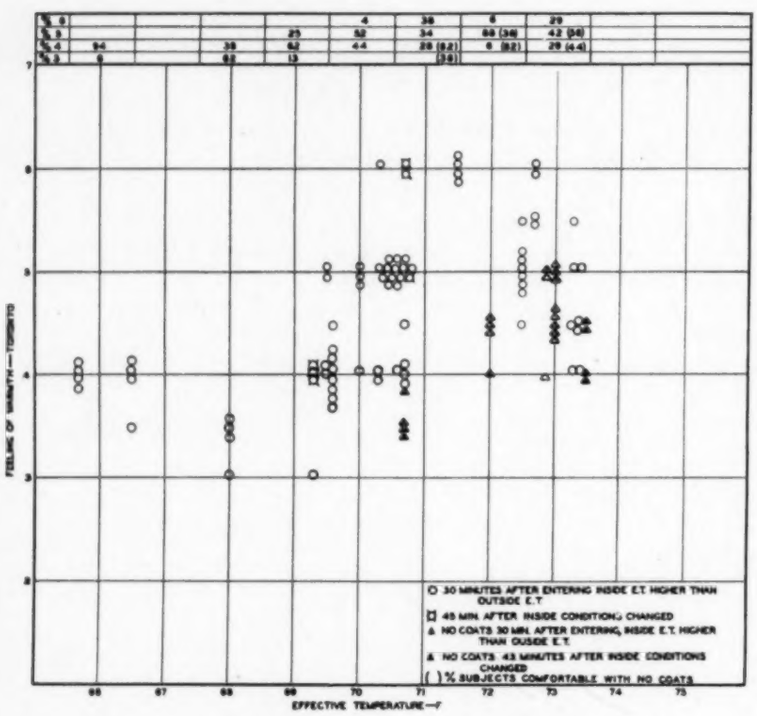

FEELING OF WARMTH—TORONTO
EFFECTIVE TEMPERATURE—F
○ 30 MINUTES AFTER ENTERING INSIDE E.T. HIGHER THAN OUTSIDE E.T.
□ 45 MIN. AFTER INSIDE CONDITIONS CHANGED
△ NO COATS 30 MIN. AFTER ENTERING, INSIDE E.T. HIGHER THAN OUTSIDE E.T.
▲ NO COATS 45 MINUTES AFTER INSIDE CONDITIONS CHANGED
( )% SUBJECTS COMFORTABLE WITH NO COATS

Fig. 2—Relation between effective temperature and feeling of warmth in Toronto on days when outside temperature was cooler than conditioned test room. Percentage of each numerical index of comfort is given in upper part of chart

This report deals with the results of the continued study during the summer of 1936 and gives extensive facts concerning items 1 to 4 above, and some added information concerning items 5 to 7.

Relation Between the Desired Effective Temperature for Summer Comfort Air Conditioning and the Weather Conditions of Different Geographical Locations

In order to indicate the degree to which different geographical locations with different weather conditions affect the indoor cooling requirements for summer air conditioning, three distinct studies were carried on during the past summer, by or in cooperation with the Research Laboratory:

1. A brief study was carried on by the Ontario Research Foundation, Toronto, Ontario.
2. A similar study was carried on by the Engineeering Experiment Station of the Agricultural and Mechanical College of Texas, College Station, Texas.
3. This and other phases of the subject outlined above were studied by the Research Laboratory of the Society in Pittsburgh.

Logs of the pertinent weather conditions in Toronto and Pittsburgh for the periods of the studies were made. (See Figs. 14 to 16).

The Toronto study was made during July, and the Texas study during July and August. The Pittsburgh study as regards this phase of the subject was made at intervals during the latter part of June, July, August and the early part of September. Included in the results analyzed in this phase of the subject are data from the similar study made and reported last year.

All three studies were carried on under approximately the same laboratory conditions as pertained in the 1935 study in Pittsburgh. In each case, an inside, well-insulated room was equipped so that it could be cooled, with provisions for controlling at will the atmospheric conditions. Tests of two general types were made in each instance. In one type of test the atmospheric conditions in the test room were made to vary slowly over a period of time along a predetermined course when plotted on the psychrometric chart, in order to traverse the probable comfort zone, or some portion thereof. The usual practice was to bring the subjects to equilibrium with a predetermined constant condition within the test room, after which the condition was made to vary slowly, while the reactions of the subjects were recorded at frequent intervals, according to the following scale of comfort which has been used in earlier laboratory reports:

"4"—comfortable.
"3"—comfortably cool, *i. e.*, that the subject was not particularly uncomfortable, but would for the sake of comfort desire a warmer rather than a cooler condition.
"2"—cool.
"1"—cold.
"5"—comfortably warm.
"6"—too warm.
"7"—hot.

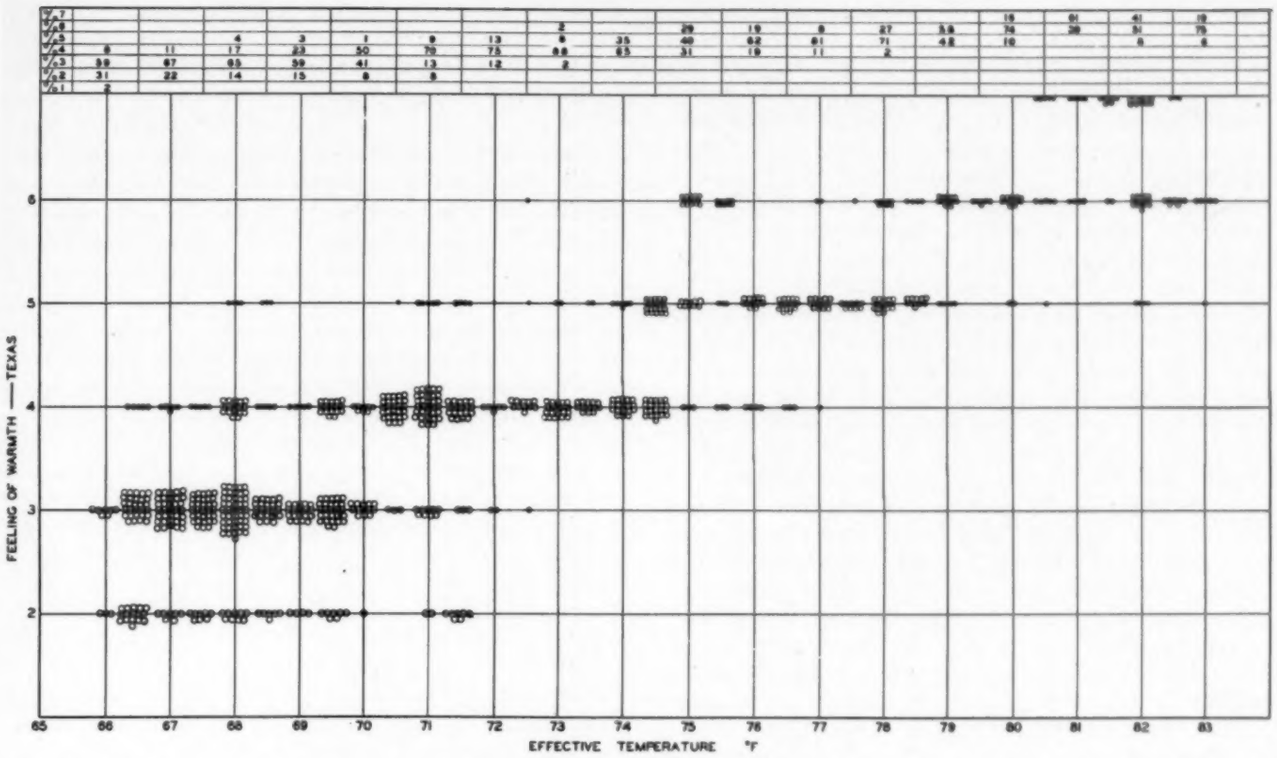


Fig. 3—Relation between effective temperature and feeling of warmth found in Texas study. Percentage of each numerical index of comfort is given in upper part of chart

At the same time, the degree of sensible perspiration was observed according to the following scale:

"0"—forehead or body, dry.
"1"—forehead or body, clammy.
"2"—forehead or body, damp (perspiration just visible).
"3"—forehead or body, wet (sweat covering the surface, frequently in drops).
"4"—perspiration on the forehead runs down, or perspiration on the body runs down or wets through clothing.

In the second type of test, the subject after a brief walk out-of-doors recorded his feeling of comfort, degree of perspiration, body temperature and other reactions before entering the conditioned room, and again immediately upon entering, and at frequent intervals thereafter, while the temperature and humidity of the atmosphere in the room were kept constant.

These subjects participating in this phase of the study were normal, healthy, college students, ranging in age from 19 to 25 years. Subjects were only accepted for the study after undergoing a medical examination, in order to eliminate those who might be abnormal in any way, particularly as regards their temperature regulatory reactions.

The comfort reactions of the subjects in the tests made at different effective temperatures in Toronto are given in Fig. 1. The feeling of warmth observed in the three

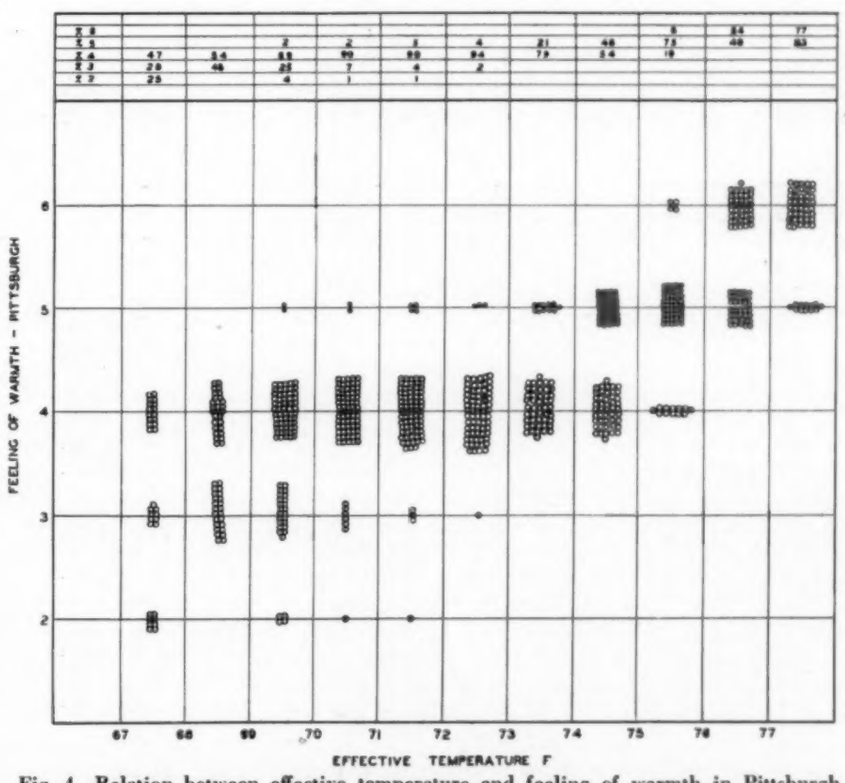


Fig. 4—Relation between effective temperature and feeling of warmth in Pittsburgh study. Percentage of each numerical index of comfort is given in upper part of chart

studies, and plotted against effective temperature in Figs. 1 to 4, show similar characteristics. In all cases the numerical index of the feeling of warmth increases with increase in effective temperature, and by inspection, the range of effective temperature over which a comfort feeling of "4" predominates may be picked out. To make this comparison easier, the percentages which the expressions of each degree of feeling of warmth are of the total number of expressions for any effective temperature are tabulated at the top of the charts. In the Toronto study, it was soon observed that on many days the outside temperature, particularly in the morning, was lower than that desired for comfort indoors. Since different reactions may be expected on cold and warm days, they are separated so that tests made on warm days are plotted in Fig. 1, and tests made on cold days are plotted in Fig. 2. The data plotted in Fig. 1, for those days when the desired inside temperature was below the outside temperature at the time of entering the test, show a comfort feeling of "4" predominating over the effective temperature range from 67.5 to 71.5 deg. The maximum percentage of observations indicating a comfort rating of "4" actually occurred at 70 deg. effective temperature.

The data plotted in Fig. 2 are for observations on days when the inside conditions were warmer than the outside conditions at the time of entering the tests. Also plotted in this chart are observations on subjects entering the tests without coats. For the subjects entering the tests with coats the maximum percentage of comfort occurred at about 69 deg effective temperature, while for subjects entering without coats (see percentages in parentheses), the highest percentage of comfort was found at from 71 to 73 deg, indicating that comfort is realized at from 2 to 3 deg effective temperature higher when no coat is worn. This will be discussed further in a later part of the paper.

The results of tests in Texas, given in Fig. 3, show a maximum percentage of 88 per cent of the subjects indicating comfort at 73 deg effective temperature, while over 50 per cent of the reactions were comfortable over an effective temperature range from 69.5 to 74.5 deg.

The results of tests in Pittsburgh, given in Fig. 4, show maximum percentage indicating comfort at between 72 and 73 deg effective temperature, with more than 50 per cent of the subjects indicating comfort between 68 and 75 deg.

In order to compare the reactions of the subjects more easily, their comfort ratings from "2" to "6" are plotted against effective temperature for the Pittsburgh study in Fig. 5. The percentages giving a comfort rating of "4," or ideal comfort, are plotted for each study in Fig. 6. While there is considerable variation between the three curves indicating a comfort feeling of "4" in the three phases of the study, particular significance is attached to the fact that maximum comfort was indicated in the Toronto study at approximately 70 deg effective temperature, while in the Pittsburgh and Texas studies maximum comfort was indicated at 72.5 and 73.0 deg effective temperature, respectively. The one-half degree variation in maximum comfort between the latter two studies is not considered to be significant, and for all practical purposes they may be considered as the same. Some significance may, however, be attached to the fact that the lower limit of comfort in the Pittsburgh study was at a lower effective temperature than that for the Texas study. On the other hand, this difference of approximately 1½ deg may result from the greater number of subjects in the Pittsburgh study. For comparison, a similar curve resulting from a study of the comfort zone in Boston by Professor Yaglou[2] in July, August and September of 1927 is also plotted. The close relation between this curve and that resulting for Toronto in this study may be due to the similarity of the summer climate of the two cities as regards their average summer temperature.

From the three curves giving a comfort feeling of "4," a comfort zone for each of the three districts may be established if agreement may be had on the percentage of persons who should be expected to be ideally comfortable in a conditioned space. If 70 per cent of all persons occupying a conditioned space should be comfortable, then the Toronto study indicates a comfort zone from a little below 68.5 to 71 deg effective temperature. The Pittsburgh study indicates a zone ranging from 69.5 to almost 74 deg, while the Texas study indicates a range from 71 to 74 deg. Keeping in mind the fact that maintaining a higher temperature results in greater economy in cooling, and also the fact that with higher effective temperatures the cold shock upon entering a conditioned space is diminished, it seems desirable to recommend for general use temperatures nearer the upper limits rather than the lower limits of these ranges. This would seem to dictate an effective temperature of 70 or 71 deg for Toronto, and about 73 deg for Pittsburgh and Texas. This would also indicate that all localities having

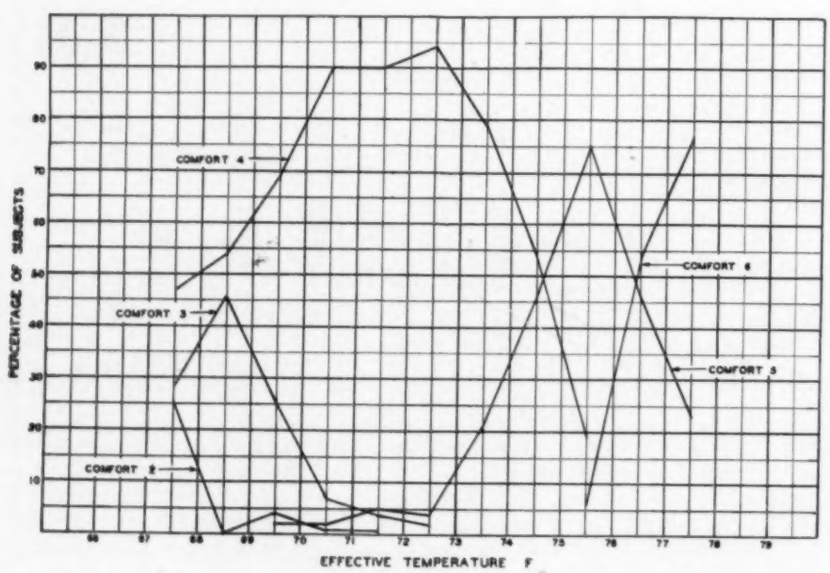


Fig. 5—Relation between effective temperature and percentage of subjects indicating different feelings of warmth for all tests made in Pittsburgh

[2]The Summer Comfort Zone: Climate and Clothing, by C. P. Yaglou and Philip Drinker. (A. S. H. V. E. Transactions, Vol. 35, 1929, p. 269).

a summer condition as warm or warmer than Pittsburgh should use summer cooling effective temperatures of about 73 deg, while for cooler climates with lower mean summer temperatures, lower effective temperatures should be maintained.

The studies here reported and the Pittsburgh study of last year indicate that no variation in the desired indoor cooling temperature accompanies a daily or even weekly change in outside weather, excepting possibly on days when the outside is cooler than the inside. It appears, rather, that the desired indoor temperature depends upon the average outside temperature during the hot season. Insofar as these deductions are true, it should be a simple matter to base the requirement for any locality on a study of its average summer temperature in relation to that of Pittsburgh and Toronto. Since the difference in the requirements of these two localities is only 2 or 3 deg, and since Toronto seems to have about as low an average temperature as any important city on the continent, possible errors in such an interpolation or extrapolation should not be great. A study of these variations is being made.

Fig. 7 shows the results of a few tests made in Toronto when the conditions within the test room were made to vary so as to follow a predetermined course when plotted on the psychrometric chart. The degree of comfort, as indicated by symbols on the curves, shows that comfort was observed for effective temperatures above 67.5 deg, agreeing fairly well with the results plotted in Fig. 6. These tests, however, indicate a higher maximum temperature for comfort than the tests plotted in Fig. 6. They also indicate a sensible perspiration line at about 76 deg effective temperature, which is in agreement with the work in the earlier study made in Pittsburgh.

Variation in Relative Humidity at a Given Effective Temperature

The study made in Pittsburgh during the summer of 1935 included a few tests which indicated that over a considerable range, variations in relative humidity did not affect the feeling of warmth, provided the proper effective temperature was maintained. This phase of the study was not, however, conclusive and the inference was the subject of considerable debate among those discussing the subject. Accordingly, a large part of the work in Pittsburgh during the past summer was directed toward clearing up this point. A series of 52 tests, all at 73 deg effective temperature, and with variations in relative humidity from 30 to 90 per cent, was made, and the results are presented in Table 1.

The most important effect of the moisture content of the air is its reaction on the feeling of warmth; however, it is recognized that it may have other important, though possibly more subtle, consequences. In this study, importance was placed primarily on its effect on the feeling of warmth. An attempt was made, however, to obtain the opinions of those participating in the test regarding other reactions experienced, as well as their general impression of conditions.

The air conditioning equipment in the Laboratory at Pittsburgh is not well adapted to maintain relative humidities above 80 per cent at dry-bulb temperatures above 70 deg during the summer, and in order to obtain these conditions it was necessary to augment the regular air conditioning system by admitting steam and spraying water into the test room. These applications frequently resulted in *steam* and other odors and the appearance of fog in some localized parts of the room. Probably as a consequence of these disturbances, the subjects frequently indicated their displeasure with the high humidities supplied, although they admitted it had nothing to do with their feeling of warmth. This phase of the subject should be given further study.

In order to eliminate the effect of the variable outside temperature, about one-half of the tests were made with the subjects entering the test room from a nearby, artificially heated room, instead of from the outside. In these tests the hot room was always maintained at 87 deg effective temperature with from 50 to 60 per cent relative humidity. The subjects remained in this hot room approximately 15 min, or in the case of each individual subject, until his feeling of warmth reached a comfort index of "7." This had the effect of giving a series of tests in which the variable effect of outside weather was eliminated. In all cases the subject entered the test room immediately after recording his feeling of warmth, degree of perspiration, and body temperature. The feeling of warmth and degree of perspiration were again recorded immediately after entering the test room and at frequent intervals thereafter during the period of the test, which lasted until all of the subjects reached a condition of comfort. Table 1 gives the feeling of warmth and the degree of perspiration on the body before entering, the feeling of warmth or the cold shock immediately after

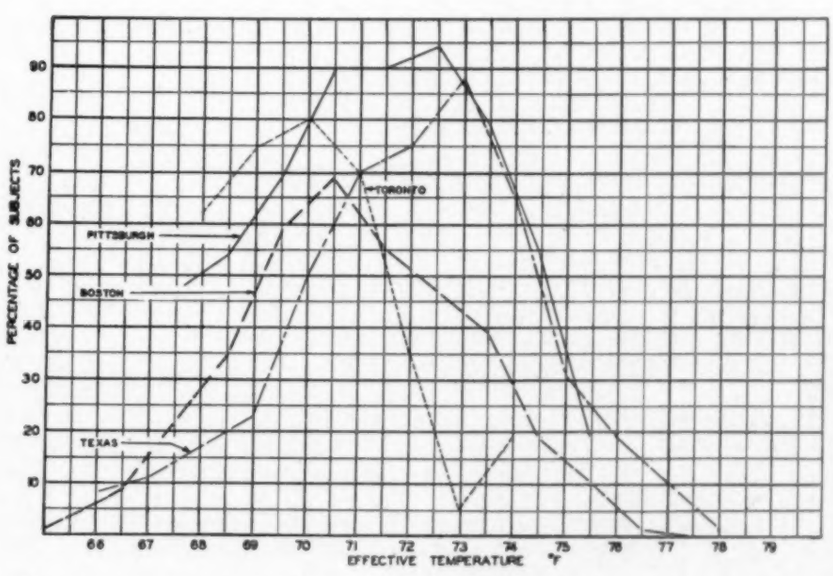


Fig. 6—Relation between effective temperature and percentage of subjects indicating a comfort feeling of 4 in Toronto, Pittsburgh, Texas and Boston

entering, the feeling of warmth at intervals after entering, and the time required for the disappearance of sensible perspiration from the forehead and from the body.

The relation between the forehead perspiration before entering the test and the time required for perspiration to disappear after entering the test is plotted in Fig. 8. Different symbols and curves give the relationship for tests in which the cooled room was entered from another hot room and for tests in which it was entered from the outside. While there is considerable variation in the test points for individual subjects in different tests, it is quite apparent that the time required for perspiration to disappear increases with the increased degree of perspiration before entering. In each case there is a slight increase in the time required for perspiration to disappear, with the same degree of perspiration before entering, when the subject entered from the outside over that required when the subjects entered from the hot room.

Table 1—Results of 52 Tests in 73 deg Effective Temperature and Various Relative Humidities in Pittsburgh After Exposure to Hot Atmospheres Either Controlled in a *Hot Room* or Encountered While Walking Outside

TEST NO.	DATE	TEST ROOM E.T.	TEST ROOM R.H.	ENTERED FROM	E.T.	R.H.	FEELING OF WARMTH B.E.	A.E.	10 MIN.	20 MIN.	30 MIN.	40 MIN.	50 MIN.	60 MIN.	DEGREE OF SENSIBLE BODY PERSPIRATION A	B	C	AVE.	BODY PERSPIRATION ENDS MIN. A	B	C	AVE.	DEGREE OF SENSIBLE FOREHEAD PERSPIRATION A	B	C	AVE.	FOREHEAD PERSPIRATION ENDS MIN. A	B	C	AVE.
30	7/7/36	73	30	HOT ROOM	87	65	7	3.0	3.7	4.0	4.0	4.0	4.0	4.0	5.0	3	3	3	14	6	22	14	2	2	3	2.3	10	10	10	10
33	7/8/36						7	2.5	3.5	3.5	4.0	4.0	4.0	4.0	—	3	3	3	—	10	30	20	—	3	3	3	—	6	6	6
34	7/8/36						7	3.0	3.0	3.5	4.0	4.0	4.0	4.0	—	2	2	2	—	20	30	25	—	2	2	2	—	8	8	8
55	7/20/36						7	2.7	4.7	4.3	4.3	4.0	4.0	4.0	4	4	4	4	15	12	20	15.7	3	3	3	3	11	20	10	14
58	7/21/36						7	2.7	4.0	4.0	4.0	4.0	4.0	4.0	3	4	4	3.7	15	20	40	25	3	3	3	3	10	12	12	11
AVE. FROM HOT ROOM							7	2.8	3.7	3.9	4.1	4.0	4.0	4.0	3.3	3.2	3.2	3.1	14.6	13.6	29.4	19.9	2.7	2.6	2.8	2.6	10	11	9	10
31	7/7/36	73	30	OUTSIDE	76	39	6.0	3.0	4	4.0	4.0	4.0	4.0	4.0	3	—	1	2.0	40	—	30	35	1	—	1	1	40	—	6	23
32	7/7/36				77.6	31.5	6.7	4.3	4	4.0	4.0	4.0	4.0	4.0	1	1	2	1.3	10	6	10	8.7	1	1	2	1.3	4	6	6	5
35	7/9/36				79	48	6.0	3.0	3.5	4.0	4.0	4.0	4.0	4.0	—	1	2	1.5	—	8	10	9	—	1	1	1	—	6	4	5
56	7/20/36				76	32	5.3	4.0	4.3	4.7	4.3	4.0	4.0	4.0	1	1	1	1.0	15	10	20	15	0.1	1	2	1.9	16	10	8	11
57	7/20/36				78.9	32.5	6.3	4.0	4.3	4.3	4	4.0	4.0	4.0	2	0	1	1.0	10	0	15	8.3	2	—	1	1	8	—	4	4
59	7/21/36				78.8	41	5.5	4.5	4.5	4.0	4	4.0	4.0	4.0	1	—	0	.5	11	—	0	5.5	1	—	0	.5	4	—	0	2
60	7/21/36				76	36	6.0	3.0	4.0	4.0	4	4.0	4.0	4.0	2	—	2	2.0	6	—	10	8	2	—	1	1.5	10	—	6	8
AVE. FROM OUTSIDE							5.8	3.7	4.0	4.1	4.1	4.0	4.1	4.0	1.6	0.75	1.3	1.3	15.3	6	13.6	12.9	1.3	1	1.1	1.1	14	7	5	6
AVE. ALL TESTS 73 E.T. 30% R.H.							6.4	3.35	3.85	4.0	4.1	4.0	4.05	4.0	2.45	2.0	2.25	2.2	15	7.1	21	14.35	2.0	1.8	2	1.8	12	9	7	9
26	7/6/36	73	50	HOT ROOM	87	72	7	3.3	3.7	3.7	3.7	3.7	4.0	4.0	3	3	3	3	25	10	20	18	2	2	3	2.3	20	6	10	12
27	7/6/36						7	3.0	4.0	4.0	4.0	4.0	4.0	4.0	2	2	3	2.3	15	10	8	10	2	2	3	2.3	20	10	10	13
36	7/9/36						7	2.7	3.0	4.0	4.0	4.0	4.0	4.0	3	3	3	3	40	14	35	30	1	3	3	2.3	6	8	15	10
37	7/9/36						6.5	2.5	4.0	4.0	3.5	3.5	3.5	3.5	3	—	2	2.5	30	—	20	25	2	—	2	2	15	—	8	12
AVE. FROM HOT ROOM							6.9	2.9	3.7	3.9	3.8	3.8	3.9	3.9	2.8	2.7	2.8	2.7	27.5	10.7	20.7	20.7	1.9	2.3	2.8	2.2	15	8	11	12
28	7/6/36	73	50	OUTSIDE	74.7	33	5.5	3.5	4.5	4.5	4.0	4.0	4.0	4.0	2	—	1	1.5	50	—	10	30	2	—	1	1.5	50	—	10	30
29	7/6/36				75.2	35	6.0	3.3	4.7	4.3	4.0	4.0	4.0	4.0	2	1	1	1.3	30	8	4	14	2	1	1	1.3	16	10	10	12
38	7/9/36				84.6	55	7.0	2.3	3.7	4.3	4.0	4.0	4.0	4.0	3	4	2	3	40	30	10	27	2	3	2	2.3	15	8	10	11
AVE. FROM OUTSIDE							6.1	3.4	4.3	4.4	4.3	4.2	4.2	4.2	2.7	2.5	1.3	1.9	40	19	8	23.7	2	2	1.3	1.7	27	9	10	18
AVE. ALL 73 E.T. 50% R.H.							6.5	3.1	4.3	4.3	4.1	4.0	4.05	4.05	2.7	2.6	2.1	2.3	33.8	14.8	14.4	22.3	1.9	2.3	2.1	2.0	21	9	11	15
5	6/24/36	73	70	H/R	87	60	7.0	2.3	3.6	3.6	4	4	4	4	3	2	2	2.3	20	10	30	20	1	2	3	2	10	10	20	13
14	6/30/36			OUT.	70.3	58	6.0	4.3	4.3	4.0	4	4	4	4	2	1	0	1	10	10	0	7	1	1	1	1	10	10	10	10
AVE. ALL 73 E.T. 60% R.H.							6.2	3.3	3.9	3.8	4	4	4	4	2.5	1.5	1	1.7	18	10	15	14	1	1.5	2	1.5	10	10	15	11.5
6	6/24/36	73	70	HOT ROOM	87	60	7	2.3	3.7	3.7	3.7	3.7	4.0	4	4	3	2	3	20	20	20	20	1	2	2	1.7	10	10	10	10
23	7/2/36						7	2.7	3.3	3.7	3.7	4	4.0	4	3	2	2	2.3	30	10	30	23	2	2	2	2	10	10	8	9
24	7/2/36						7	2.3	3.3	3.3	3.7	3.7	3.7	3.7	4	3	2	3	20	30	50	33	2	3	2	2.3	10	20	20	17
39	7/10/36						7	2.3	3.3	3.3	3.3	3.7	3.7	3.7	3	3	3	3	40	30	60	43	2	3	3	2.7	10	20	2	17
AVE. FROM HOT ROOM							7	2.4	3.4	3.5	3.6	3.8	3.9	3.9	3.5	2.9	2.5	2.8	28	22	40	27	1.8	2.5	2.3	2.2	10	15	15	13
25	7/3/36	73	70	OUT SIDE	75	58	5	4	4.0	4	4.0	4.0	4	4	1	1	0	7	16	6	0	7	1	1	1	1	8	4	6	6
40	7/10/36				82	55	7	2.5	4.0	4	4.0	3.5	—	—	2	—	3	2.5	30	—	10	20	2	—	3	2.6	30	—	10	20
41	7/10/36				80.4	44.5	7	2.3	3.7	3.7	3.7	3.3	3.7	3.7	3	3	3	3	40	30	40	33	2	2	2	2	30	20	10	20
AVE. FROM OUTSIDE							5.6	3.9	3.9	3.9	3.9	3.6	3.8	3.8	2	2	2	3.8	39	18	17	20	1.6	1.5	2	1.8	23	12	9	15
AVE. ALL 73 E.T. 70% R.H.							6.3	3.2	3.9	3.9	3.8	3.7	3.8	3.8	2.8	2.4	2.3	3.2	34	20	28	24	1.7	2	2.2	2	17	14	12	14
7	6/25/36	73	80	HOT ROOM	87	60	7.0	2.3	3.7	3.7	4.0	4.0	4.0	4	4	3	4	3.7	30	40	50	40	1	3	3	2.3	10	10	20	13
19	7/1/36						6.3	2.7	3.3	3.3	3.7	4.0	4.0	4	2	2	2	2	20	30	60	37	2	2	2	2	10	10	30	17
20	7/2/36						6.7	2.7	3.3	3.7	3.3	3.3	3.3	3.3	4	2	2	2.7	40	10	40	30	2	1	2	1.7	10	10	20	13
44	7/6/36						7.0	2.3	3.3	3.7	4.0	4.0	4.0	4	3	3	3	3	30	30	30	30	2	3	3	2.7	10	20	20	17
61	7/24/36						7.0	2.7	3.7	4.0	4.0	4.0	4.0	4	3	3	3	3	20	10	40	23	3	5	3	3	8	10	8	9
AVE. FROM HOT ROOM							6.9	2.6	3.6	3.7	3.8	3.9	3.9	3.9	3.2	2.6	2.8	2.9	28	24	44	32	2	2.4	2.6	2.3	9.6	12	10	14
18	7/1/36	73	80	OUT SIDE	67.6	70.5	3.7	5.0	4.3	4.0	4.0	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
53	7/17/36				78.5	51	6.3	3.7	4.7	4.7	4.3	4	4	—	1	1	0	.7	30	30	0	20	1	1	—	0.6	8	7	—	8
54	7/17/36				78.4	28.5	6.0	3.0	4.3	4.3	4.7	4	4	4	2	1	1	1.3	30	10	10	17	1	1	1	1.0	8	6	6	7
62	7/24/36				77.6	48	6.3	3.7	3.7	3.7	4.0	4.0	4	4	0	0	1	0.3	0	0	4	1.0	—	—	—	—	—	—	—	—
AVE. FROM OUTSIDE							6.2	3.8	4.2	4.2	4.3	4	4	4	1	0.5	0.5	0.6	20	10	8.6	11	8.6	0.6	0.5	0.7	5.3	6.3	3	5
AVE. ALL 73 E.T. 80% R.H.							6.1	3.2	3.9	3.9	4.2	4	4	4	2.1	1.6	1.7	1.9	24	17	23.8	16.5	1.3	1.5	1.4	1.5	7.5	8.6	11.5	9.5
42	7/13/36	73	90	HOT ROOM	87	55	7	2.5	3.5	3.5	3.5	4.0	4	4	4	—	3	3.5	30	—	40	35	3	—	3	3	15	—	15	15
46	7/15/36						7	2.7	3.0	3.7	3.7	3.7	4	4	3	3	3	3	20	40	30	30	2	3	3	2.7	20	30	20	23
49	7/16/36						7	2.7	3.3	3.7	3.7	3.7	4	4	3	3	3	3	30	20	40	30	2	3	3	2.7	8	20	24	16
63	7/27/36						7	3.0	3.7	4.0	4.0	4.0	4	4	3	3	3	3	20	10	70	13.8	2	3	3	2.7	10	8	8	9
66	7/28/36						7	3.0	3.3	4.0	4.0	4.0	4	4	4	3	4	3	20	10	40	23.3	3	3	3	3	20	8	20	16
AVE. FROM HOT ROOM							7	2.8	3.4	3.8	3.8	3.9	4	4	3.4	2.4	3.2	3.2	24	20	32	26	2.4	3	3	2.8	15	17	17	16
43	7/13/36	73	90	OUT SIDE	81.2	45	5.3	3.3	3.7	4	4	4	4	4	1	3	1	1.7	8	30	15	18	1	3	1	1.7	6	15	15	12
45	7/14/36				77.8	52	6.3	2.3	4.3	4	4.7	4	4	4	2	2	3	2.3	30	40	30	33	2	2	3	2.3	20	40	10	23
47	7/15/36				80.2	56	6.3	3.7	4.3	4.3	4	4	4	4	3	1	1	1.7	6	30	10	15	1	2	1	1.3	6	30	2	13
48	7/15/36				80.8	53.5	7.0	3	4.7	4	4	4	4	4	2	2	1	1.7	20	20	10	17	2	2	2	2	20	20	2	15
50	7/16/36				82.2	36.5	6.0	3	4.3	4.3	4	4	4.3	4	1	1	1	1.0	20	10	2	11	1	1	1	1	6	8	2	5
51	7/16/36				77.8	31.5	5.3	3	4	4	4	4	4	4	1	1	1	1.0	18	4	10	11	1	1	1	1	4	4	8	5
64	7/27/36				81.1	58	6.0	3	4	4	4	4	4	4	2	—	2	2.0	30	—	30	30	1	—	2	1.5	10	—	20	15
65	7/27/36				82	66	6.0	3	4.7	4.3	4	4	4	4	2	3	2	2.3	20	20	50	30	2	3	2	2.3	10	10	8	9
67	7/28/36				78.6	56	4.3	3.7	4	4	4	4	4	4	0	1	0	.3	0	6	0	2	—	1	—	0.3	—	4	—	1
68	7/28/36				78.4	55	6.3	3	3.7	4	4	4	4	4	1	2	1	1.3	4	8	30	14	1	2	1	1.3	2	8	8	6
AVE. FROM OUTSIDE							6.7	3.1	4.2	4.1	4.1	4	4	4	1.6	1.7	1.5	1.6	16	20	19	18	1.3	2	2	1.6	9	16	9	10
AVE. ALL 73 E.T. 90% R.H.							6.4	3	3.8	3.9	3.9	4	4	4	2.6	2.1	2.2	2.3	20	20	26	22	1.8	1.6	1.6	2.2	12	16	13	13

This may be accounted for by the fact that the hot room was usually at a higher temperature than the outside, so that the subjects reached the high degree of perspiration indicated in a shorter period of time and with less rise in body temperature.

The curves for the five different relative humidities show no measurable progressive change from lower to higher moisture content of the air. The curves as drawn from the data show that 10.5, 16.5, 16, 15 and 14 min were required for sensible perspiration to disappear in atmospheres of 73 deg effective temperature and 30, 50, 70, 80 and 90 per cent relative humidity, respectively, when a perspiration rate of "2" pertained before entering the test room from the outside. Similarly, 8, 10.5, 10.5, 10 and 8.5 min were required for the disappearance of sensible perspiration from the subjects in atmospheres of 73 deg effective temperature and 30, 50, 70, 80 and 90 per cent relative humidity, respectively, after entering the test room from the hot room with a sensible perspiration rate of "2." Observations plotted in Fig. 8 show that in a number of cases perspiration lingered longer in atmospheres of 80 and 90 per cent relative humidity than

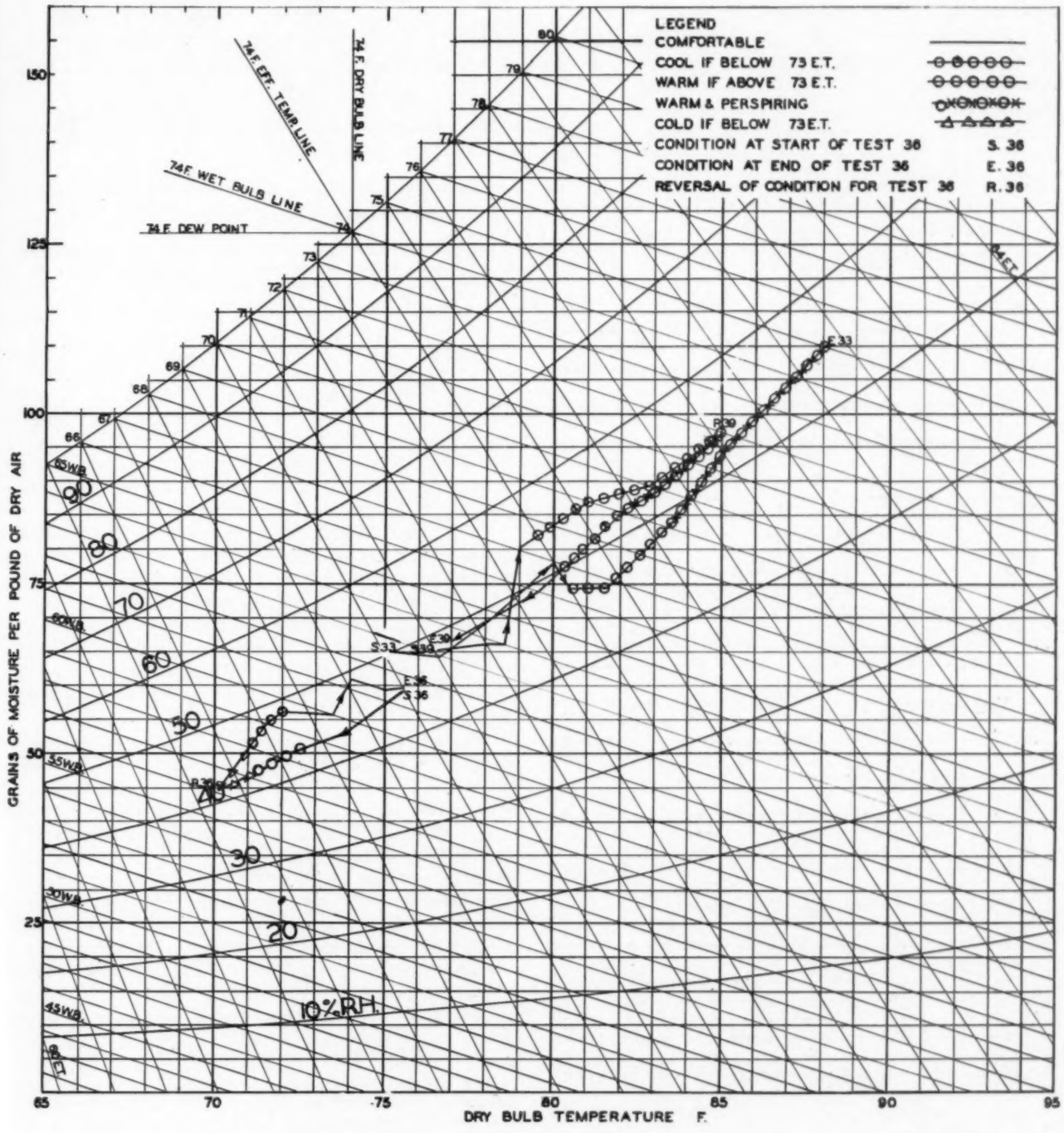

LEGEND
COMFORTABLE
COOL IF BELOW 73 E.T.
WARM IF ABOVE 73 E.T.
WARM & PERSPIRING
COLD IF BELOW 73 E.T.
CONDITION AT START OF TEST 36 S. 36
CONDITION AT END OF TEST 36 E. 36
REVERSAL OF CONDITION FOR TEST 36 R. 36
74 F. EFF. TEMP. LINE
74 F. DRY BULB LINE
74 F. WET BULB LINE
74 F. DEW POINT
GRAINS OF MOISTURE PER POUND OF DRY AIR
DRY BULB TEMPERATURE F.
10% RH.

Fig. 7—Variation in atmospheric conditions maintained during three tests in Toronto and the reactions of the subjects to these conditions

in lower humidities. While there is some indication of a slightly increased length of time for the disappearance of perspiration in high relative humidities, the increase is less than the errors in measuring the effect or the variations resulting from different individuals at different times. The variations, may, therefore, be assumed to be of no significance. This is contrary to what might logically be expected from general experience in the rates of drying of various materials in air of the same temperature but with different relative humidities. It must be kept in mind, however, that the disappearance of sensible perspiration is more than an ordinary drying process. The disappearance of perspiration must be greatly affected by the time necessary for the body to cease exuding perspiration after entering an atmosphere of lower temperature. Also, the evaporation of perspiration from the body of a person is affected both by the temperature and moisture content of the air and the temperature of the body itself. Since the surface temperature of the body, even when under the greater cooling rate met with in the cooled atmosphere, does not fall greatly, the vapor pressure of the moisture on the surface is considerably higher than the vapor pressure of the atmosphere at 73 deg effective temperature with either high or low relative humidity. From this point of view, the apparent insignificance of the change in disappearance of perspiration with change in relative humidity becomes less surprising. Further study of this phase of the subject is recommended.

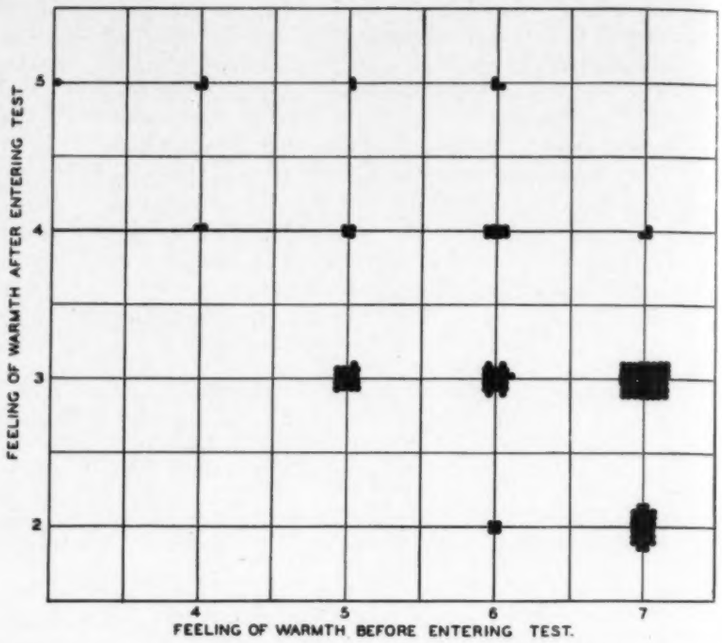


Fig. 9—Relation between feeling of warmth before entering test and shock or feeling of cold immediately after entering an atmospheric condition of 73 deg E T and various relative humidities

One should expect to find a significant correlation between the degree of perspiration before entering a cooled atmosphere and the time required to reach comfort after entering. A similar correlation should be expected between the feeling of warmth before entering a cooled atmosphere and the time required to reach comfort after entering. However, plotting these relationships from the data in Table 1 shows no significant correlation.

The relation between the cold shock or the feeling of discomfort immediately after entering a cooled atmosphere, at 73 deg effective temperature with various relative humidities, and the degree of perspiration on the body before entering on the one hand, and the feeling of warmth before entering the conditioned space on the other, are shown in Figs. 9 and 10. There is a reasonably good correlation in both cases, showing that the cold shock upon entering a cooled space increases with the degree of warmth and the degree of perspiration experienced before entering. As the feeling of warmth before entering increases from "4" to "7," the feeling of warmth or the cold shock immediately after entering decreases

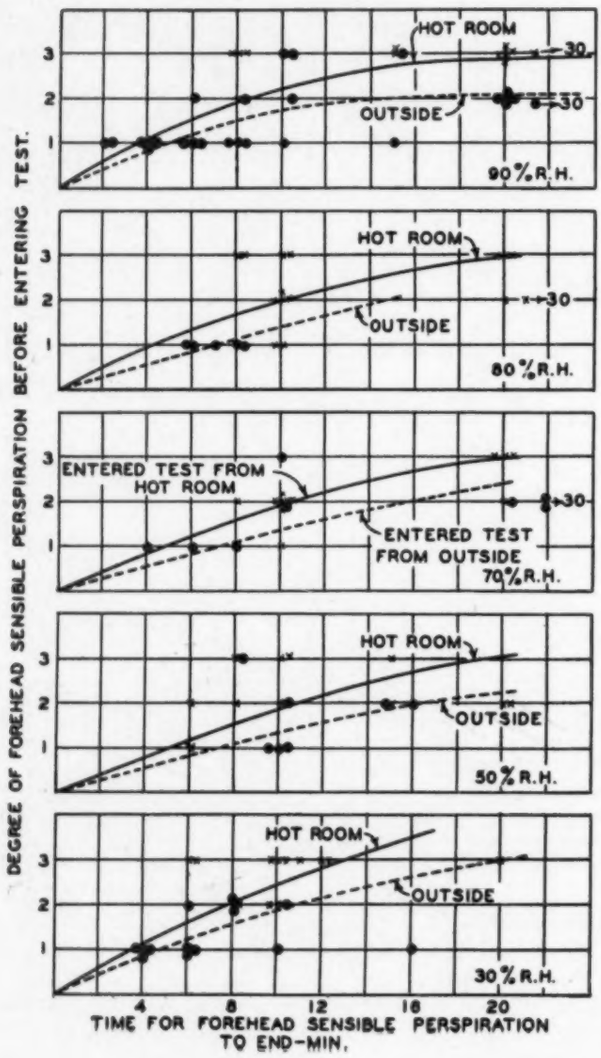


Fig. 8—Relation between degree of sensible perspiration on foreheads of subjects before entering tests and time required for sensible perspiration to disappear in atmospheres of 73 deg E T and various relative humidities. Symbols (x) and solid line curves for tests following exposure to 87 deg E T in a hot room; circles (o) and broken line curves for tests following exposure to hot outdoor conditions

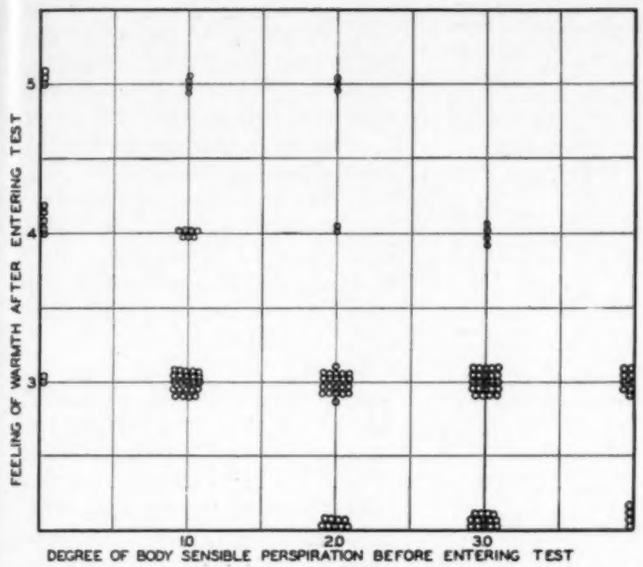


Fig. 10—Relation between feeling of sensible perspiration on body before entering test and shock or feeling of cold immediately after entering an atmospheric condition of 73 deg E T and various relative humidities

from approximately "4" to "2.5," and, while the degree of perspiration before entering increases from "0" to "4," the cold shock after entering decreases from "4" to "2.5." There is no noticeable variation in these relationships for tests made at different relative humidities and 73 deg effective temperature, proving rather conclusively that the cold shock upon entering a cooled space is independent of the relative humidity at a given effective temperature.

The relation between time required for sensible perspiration to disappear from the body and the time required to reach comfort after entering a cooled atmosphere at 73 deg effective temperature and various relative humidities is shown in Fig. 11. The data do not indicate any definite curve or relationship; however, the fact that few test points are found in the lower right hand portion of the chart, particularly to the right and below a line through the "10 min comfort—zero perspiration" and the "50 min comfort—40 min perspiration" points, indicates that comfort is almost always reached not later than 10 min after the disappearance of body perspiration, and that it may be reached earlier. This involves a fine point in consideration of comfort. Strictly speaking, it may be assumed that no one is comfortable while still moist with perspiration. However, in these tests, comfort based upon a feeling of warmth only was more strongly emphasized. Instances where perspiration lingered after a comfortable feeling of warmth was registered probably include only cases where considerable perspiration was held on the body and in the clothing before entering the test, which evaporated rather slowly and hence did not greatly affect the feeling of warmth. As a corollary to the above assumption, it may likewise be stated that perspiration rarely disappeared earlier than 10 min before a comfortable feeling of warmth was established.

The relation between the length of time, after entering the conditioned space, required to establish comfort and the time for sensible perspiration to disappear from the forehead is given in Fig. 12. No sharp relationship is noted but the general distribution of the points indicates the reverse of that brought out by Fig. 6. Few points are found in the upper left hand part of the chart showing that forehead perspiration usually disappears before comfort is established and rarely more than 10 min later.

Rise in body temperature resulting from exposure to, and exercise in, hot atmospheres may be assumed to have a material effect on the time required to reach comfort. This relationship is shown in Fig. 13. While the test points show no close relationship, there is an apparent tendency for the time required to reach comfort to increase with the degree of body temperature above normal at the time of entering the test.

Relation Between the Age, Sex and Health of Subjects, and the Clothing Worn by Them, and the Required Effective Temperature for Summer Comfort Air Conditioning

A most important question concerning cooling requirements for summer comfort air conditioning is the possible variation in the desired indoor air temperature based upon the age, sex and health characteristics of the persons involved. A comprehensive study of this phase of the subject was planned, but only relatively few data have been made available, and further study is urgently needed. During the latter part of the summer, men and women of various walks in life and of different ages were induced to enter the conditioned rooms and give their opinions concerning their feeling of warmth and other reactions. The results of this survey are shown in Table 2. These tests indicate in general the same temperature requirement for comfort as indicated by the trained subjects.

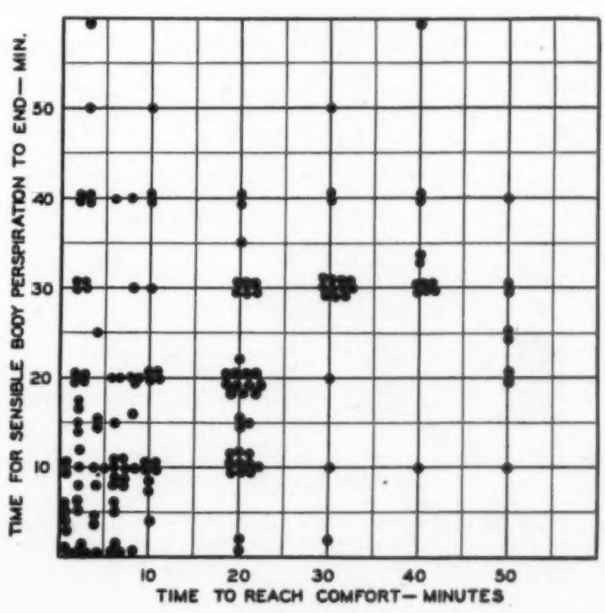


Fig. 11—Relation between time required for subjects to reach comfort and time for sensible body perspiration to disappear for all subjects entering tests at 73 deg E T and various relative humidities

Table 2—Reactions of Men and Women Before and After Entering Various Conditions; the Reactions During *Warm Weather* on Days When the Outside Effective Temperature Was Above That in the Test Room, and for *Cool Weather* on Days When the Outside Effective Temperature Was Below That Maintained in the Test Room

TEST ROOM E.T.	TIME	MEN								WOMEN							
		COATS				NO COATS				WARM WEATHER				COOL WEATHER			
		No.	UNDER 40	No.	OVER 40	No.	UNDER 40	No.	OVER 40	No.	UNDER 40	No.	OVER 40	No.	UNDER 40	No.	OVER 40
70	Before Entry	10	4.3	6	5.0	25	5.1	4	4.5					9	5.8*	7	5.8*
	After Entry		3.5		3.6		2.4		3.5						3.3		3.3
	10–25 Min.		3.9		3.7		3.3		3.5						4.0		4.0
	After 25 Min.		3.9		3.7		3.5		3.5						4.0		4.0
	Outside		6.0		5.0		5.2		5.3						6.0		5.3
73	Before Entry	8	5.3	10	5.1	37	5.0	12	4.7	12	4.7			26	6.1*	12	6.0*
	After Entry		3.0		3.4		3.0		2.9		3.5				4.2		4.1
	10–25 Min.		4.1		4.0		4.0		3.7		4.3				4.2		4.3
	After 25 Min.		4.1		4.0		3.9		4.0		4.0				4.3		4.3
	Outside		5.7		4.9		5.3		5.1		4.7				5.9		5.6
75	Before Entry	7	6.0	11	4.7	23	5.4	15	5.0								
	After Entry		4.3		4.0		3.8		3.9								
	10–25 Min.		5.0		4.6		4.0		4.3								
	After 25 Min.		5.0		4.6		4.0		4.0								
	Outside		5.0		4.7		5.4		5.1								
78	Before Entry			7	5.3	5	5.0	4	5.0					12	6.0*		
	After Entry				5.2		4.0		4.0						3.9		
	10–25 Min.				5.5		4.6		4.5						4.6		
	After 25 Min.				5.5		4.8		4.5						4.9		
	Outside				6.0		5.4		5.5						5.8		
77	Before Entry			2	5.0	6	6.0	4	5.2	4	5.0	4	5.5*				
	After Entry				5.0		3.7		3.6		4.0		3.5				
	10–25 Min.				6.0		4.3		5.0		5.0		4.7				
	After 25 Min.				6.0		5.0		4.8		5.0		4.5				
	Outside				6.0		5.3		5.4		5.0		5.0				

*Subjects exposed to hot atmospheres in another room before entering tests.

Men, both under and over 40 years of age, wearing coats, showed an average degree of warmth a little below "4" at 70 deg effective temperature, approximately "4" at 73 deg, and too warm at higher effective temperatures. There is a slight, though not pronounced, expressed desire for a higher temperature by the men over 40 years of age. However, this is not very significant. It would be of considerable interest to have similar data on the two age groups for lower temperatures, where a considerable feeling of coolness would pertain. Such tests could not be made in the short period available.

A considerable number of the men available for test appeared and entered the room without wearing coats, but otherwise dressed similarly to the trained subjects. These men show a measurably higher temperature requirement for comfort over that indicated for men wearing coats. The apparent difference is about 2, or possibly as high as 3 deg. The data collected in Toronto and plotted in Fig. 2 show about the same difference.

It was more difficult to get women of various walks of life and age distribution to enter the test rooms. The twelve women below 40 years of age entering the test rooms were employees of the Pittsburgh Station of the Bureau of Mines. They were largely members of the clerical staff. Their average indication of comfort was not materially different from that for men of the same age. Late in the season, or on the 17th and 18th of September, 40 members of the Bureau of Mines Women's Club, largely made up of wives, other relatives, and friends of the employees of the Bureau, arranged to enter the test rooms and give their opinion of the conditions. These arrangements had to be planned several days in advance and unfortunately the days on which the tests were made turned out to be rather cool, about 67 deg effective temperature. These

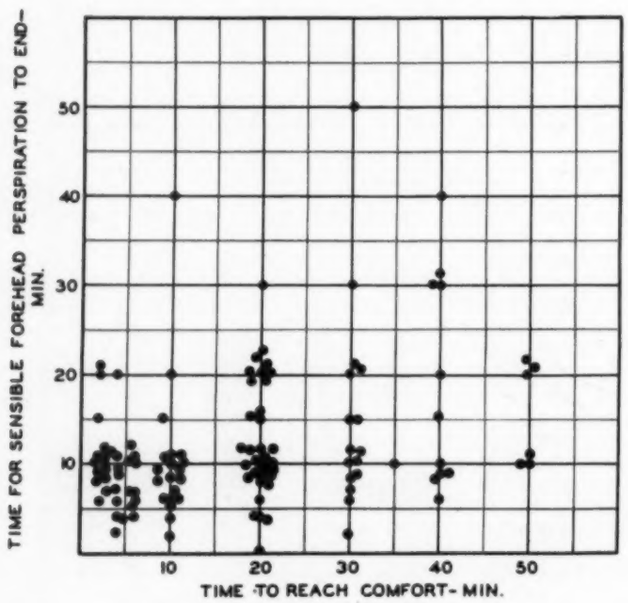


Fig. 12—Relation between time required for subjects to reach comfort and time for sensible forehead perspiration to disappear for all subjects entering tests at 73 deg E T and various relative humidities

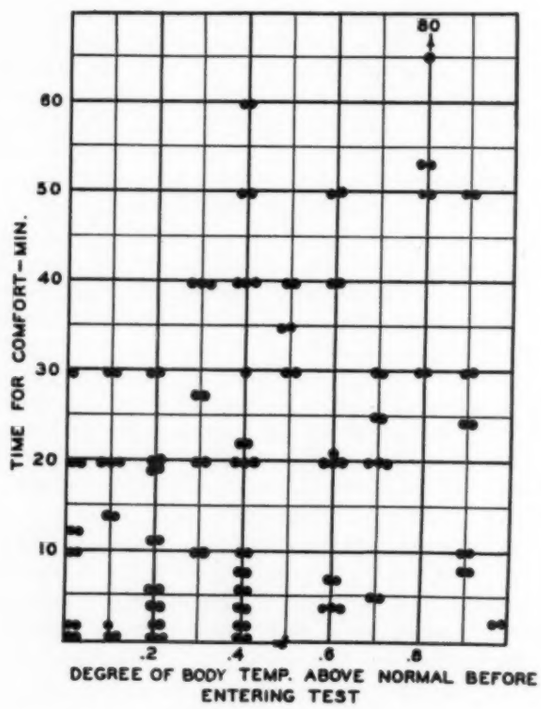


Fig. 13—Relation between elevation of body temperature above normal before entering test to time required for the establishment of comfort after entering atmospheres of 73 deg E T and various relative humidities

women were dressed somewhat warmer than is customary for normal summer weather, and uniformly registered a degree of warmth of "4," or ideally comfortable, at 70 deg effective temperature, and slightly too warm for comfort at 73 deg. Before entering the test room, these women spent about 15 min in a room at about 78 deg effective temperature, which accounts for the high degree of warmth registered before entering.

Effect of Air Motion

A few tests were made with from three to five subjects to determine the desired temperature for comfort with higher than normal air velocities. These tests were made late in the season, and sufficient data for drawing any definite conclusion were not obtained. However, these few data serve to indicate that the effective temperature scale for moving air first published[3] by the Laboratory in 1924, for persons stripped to the waist, and later[4] corrected for persons normally clothed, applies reasonably well. These earlier studies were based upon tests at air velocities of 25, 150 and 300 fpm, and the effects for velocities between 25 and 150 fpm were determined by interpolation. The few studies made in this investigation for velocities ranging from 75 to 120 fpm indicate a greater cooling of from 1 to 2 deg than given by the earlier interpolated results, while for tests in velocities ranging from 120 to 300 fpm, the earlier published data appear to be correct. However, it should be emphasized that the number of observations made on the effect of air velocities were too few in number to be considered conclusive. Based upon the above indications, an air velocity of 75 fpm results in comfort with 82 F dry-bulb at 50 per cent relative humidity, and with 78 F dry-bulb at 80 per cent relative humidity. The subjects endured air velocities up to 150 fpm for periods up to one hour without complaint. Velocities above 150 fpm, even for periods of 15 or 20 min, were found objectionable, while velocities from 100 to 150 fpm for periods of over an hour became irritating and unpleasant.

[3]Cooling Effect on Human Beings Produced by Various Air Velocities, by F. C. Houghten and C. P. Yagloglou (A. S. H. V. E. TRANSACTIONS, Vol. 30, 1924, p. 193.)

[4]Effective Temperature with Clothing, by C P. Yaglou and W. Edw. Miller. (A. S. H. V. E. TRANSACTIONS, Vol. 31, 1925, p. 89.)

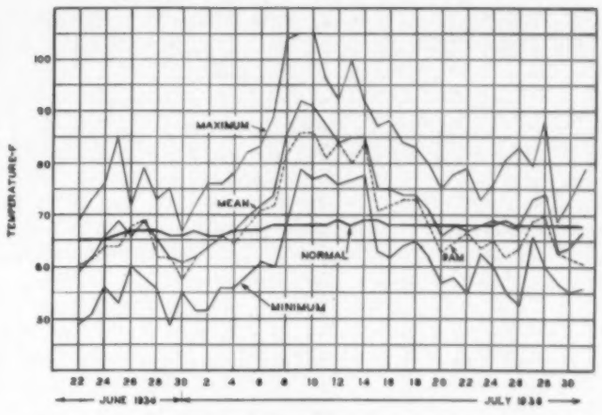


Fig. 14—Log of weather conditions in Toronto June 22 to July 31, 1936

Shock Upon Entering or Leaving a Cooled Atmosphere

The plans outlined for the investigation by the Technical Advisory Committee on Comfort Requirements for Summer Cooling included a more intensive study of the cold shock upon entering a conditioned space, and the reaction upon re-entering the hot outside. Time was not available for any specific tests on this phase of the subject. However, occasional observations while making the studies reported above, and analyses of a few tests available at different effective temperatures, indicate quite clearly that the severity and length of the cold shock increases rapidly as the effective temperature of the cooled space is lowered, pointing to the desirability of maintaining as high an effective temperature indoors as will give comfort, or an effective temperature in the upper region of the comfort zone.

While few observations were made on the effect of the reaction upon re-entering the hot outside from the cooled space, it was apparent that the reaction decreased with a higher effective temperature maintained indoors. The few observations made, together with the general reactions and opinions of the subjects taking part in the tests, indicate no very severe reaction, and it is believed that the objection frequently directed to air conditioning because of this reaction is largely psycho-

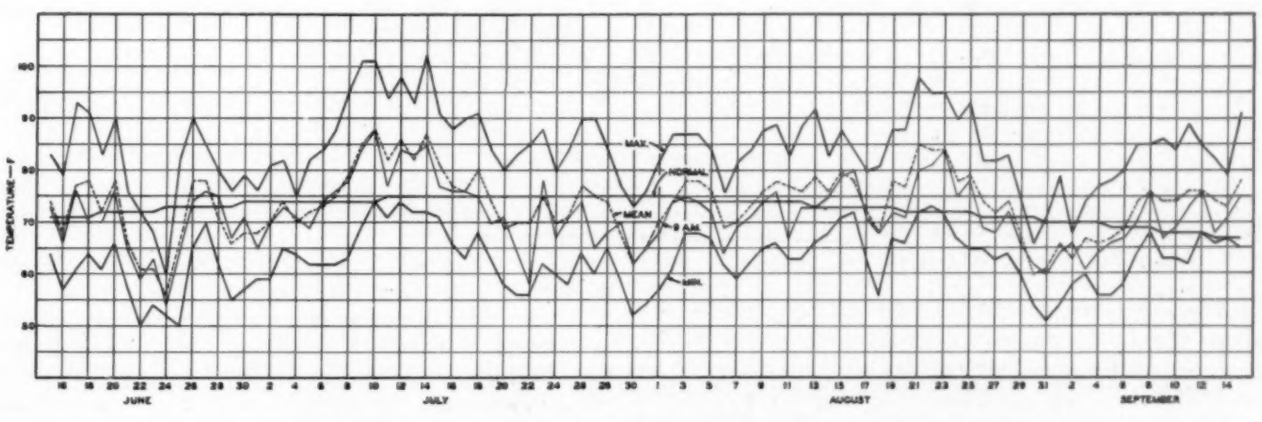


Fig. 15—Log of weather conditions in Pittsburgh June 12 to September 15, 1936

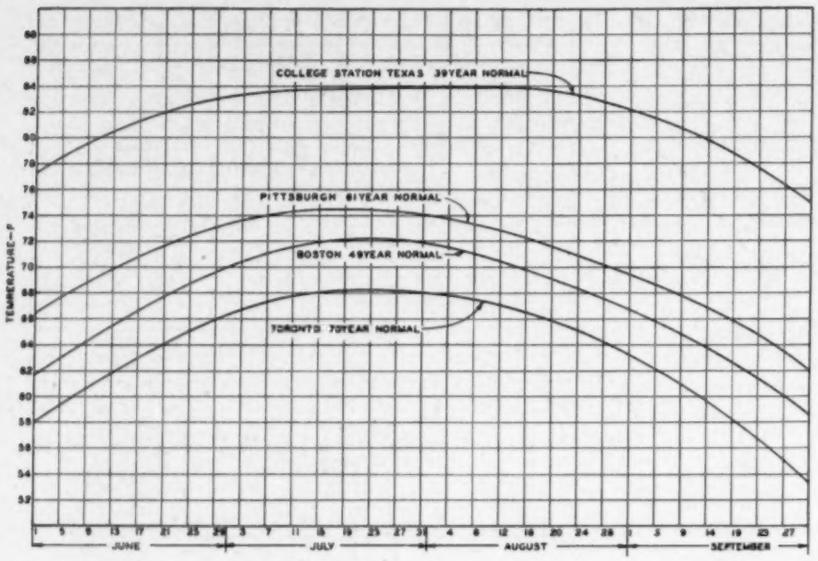


Fig. 16—Normal summer temperatures reported by weather bureau for Texas, Pittsburgh, Boston and Toronto

logical. Apparently, from the few observations made, recovery to complete normal reactions after re-entering the hot outside (if such reactions can be considered normal), was reached as soon as perspiration was re-established. Upon re-entering the hot outside, the reverse in physiological reactions takes place from those upon entering the cooled space. Before leaving the cooled space, a person's heat dissipation is in equilibrium with the cooled condition, and the rate of heat production and adequate heat dissipation results without sensible perspiration. As soon as this person re-enters the hot atmosphere, equilibrium is destroyed and the body ceases to dissipate heat to the atmosphere at the normal rate, because sensible heat dissipation has been decreased with no compensation by increased evaporation. Equilibrium, and hence, a normal feeling of warmth, does not result until normal perspiration for the hot condition has been re-established. A few observations of this reaction indicate that from 5 to 15 min is required to re-establish perspiration. This time is apparently shortened by exercise.

The subjects never complained of discomfort during the hours following a cool test other than for the short period mentioned above, excepting that their greater comfort during the test period emphasized the discomfort resulting from the hot outside atmosphere.

Review of the Results of the Study

The study of the cooling requirements for comfort in summer air conditioning in Toronto, Texas and Pittsburgh confirm the findings of a year ago that comfort may be had over a small effective temperature range, which is independent of daily or even weekly variations in outside weather. The results show clearly that with the weather conditions of last July in Toronto, an effective temperature of from 2 to 3 deg lower was required for comfort than was the case in Pittsburgh. Similar studies made in Texas prove rather conclusively that for their hotter, more continuous and longer summer heat, the same effective temperature is required as was found for Pittsburgh. In Toronto, 70 per cent of the subjects were found to be comfortable over a range of effective temperatures from 68.5 to 71 deg; in Pittsburgh from 69.5 to 74 deg; and in Texas from 71 to 74 deg.

In order to minimize the cold shock upon entering a conditioned space, as well as to economize in the cost of cooling, an optimum effective temperature for air conditioning purposes is recommended near the upper limits of the comfort zone, or 71 deg effective temperature for Toronto, and 73 deg for localities having summer conditions as hot or hotter than Pittsburgh.

An intensive study of the relation of comfort to relative humidity with constant effective temperature indicates little or no measurable variation in the time required for perspiration to disappear and for comfort to be established in a relative humidity range from 20 to 90 per cent. However, a recommendation for the use of relative humidities of 80 per cent or higher must be given with reservation, due to the difficulty experienced in properly supplying these higher humidities in the summer with the air conditioning system available.

Sixty-one men, ranging from 20 to 65 years in age, were found to be comfortable over approximately the same temperature range as the trained, young subjects. A slightly higher temperature was indicated as desirable by men over forty. Few data were obtained for women of different age groups under satisfactory weather and environmental conditions, but these few observations indicate no material difference in the degree of cooling desired over that found for men.

Clothing was found to have a material effect on the desired temperature for comfort. The wearing of a lightweight coat apparently decreases the temperature required for comfort by from 2 to 3 deg. Hence, the removing of such a coat raises the maximum temperature for comfort by 2 or 3 deg.

Acknowledgement is due to the Canadian Westinghouse Co., Ltd., the Minneapolis-Honeywell Regulator Co., Ltd., the C. A. Dunham Co., Ltd., and the Canadian General Electric Co., Ltd., for their cooperation in the loan of the equipment used in the tests made at the Ontario Research Foundation, Toronto.

Ultra Violet in the Solar Spectrum

Calculations and graphs showing the distribution of energy in the extreme ultra violet of the solar spectrum for various air masses traversed by the rays is given in the National Bureau of Standards Paper No. RP899 of the July 1936 *Journal of Research*, Vol. 17. Also the spectral energy distribution of solar radiation outside the earth's atmosphere is referred to in this work.

A portion of the paper refers to the progress made in assembling apparatus for measuring the spectral quality and total intensity of ultra violet solar radiation by means of a photo-electric cell transported aloft in sounding balloons.

Performance of Oil-Fired, Warm-Air Furnaces in the Research Residence

By A. P. Kratz* and S. Konzo** (*MEMBERS*), Urbana, Ill.

THE investigations in forced-air heating in the Research Residence at the University of Illinois during the period from 1932 to 1934 were largely confined to studies of the characteristics of the forced-air heating system,[1] to studies of automatic controls,[2] and to studies of the effectiveness of storm windows[3] under actual service conditions. For these investigations the fuel used was anthracite. The investigation for the heating season of 1934-1935 was undertaken to determine the performance and operating characteristics of a warm-air furnace equipped with a conversion oil burning unit. For the heating season of 1935-1936 the conversion oil-burning furnace unit was replaced with a warm-air furnace designed specifically for oil combustion, and the performance and characteristics of the furnace were compared under identical conditions of operation with those obtained with the conversion unit.

Fig. 1—View of Research Residence in Urbana, Ill.

Description of the Research Residence and Heating Equipment

The Research Residence, shown in Fig. 1, together with the forced-air heating system has been described in previous papers.[2, 3] The residence is a three-story structure of standard frame construction. The wall section consists of weather-boarding, building paper, sheathing, 6-in. studding, wood lath, and plaster with rough sand finish. The walls are not insulated and no weather stripping is used at the windows and doors. All the tests reported in this paper were made with ordinary, double-hung windows tightly locked.

The total space heated during these tests consisted of three rooms, a sun room, a breakfast nook, and a hallway on the first story; three rooms, a bathroom, and a hallway on the second story; and two rooms, a bathroom, and a hallway on the third story. The total volume of this heated space, from which the basement was excluded, was approximately 17,540 cu ft. The calculated heat loss was approximately 137,500 Btu per hour at an indoor-outdoor temperature difference of 70 F, and approximately 159,000 Btu per hour at an indoor-outdoor temperature difference of 80 F. The residence is completely furnished, and during the heating season it was occupied by four people.

The heating plant consisted of a warm-air furnace used in connection with a forced-air heating system. The duct system is shown in Fig. 2. Three cold-air returns were used which were connected to a cold-air box above the inlet to a centrifugal type fan. The furnace was placed at the east end of the basement, and the warm-air registers were served from two main trunk systems. The furnace used during the heating season of 1934-1935, shown in Fig. 3, was of the cast-iron, circular-radiator type, having a 27-in. firepot and 23-in. grate, and was equipped with a casing 50-in. in diameter. In order to accommodate the gun-type oil burner which was inserted through the ash-pit door of the furnace, the grates were removed and firebrick were arranged to form a cylindrical combustion space as shown in Fig. 3. Hereafter this combination of the furnace and burner will be referred to as the conversion unit.

During the heating season of 1935-1936 the furnace used, shown in Fig. 4, was of steel construction especially designed for oil burning. This furnace will be referred to hereafter as the oil-burning furnace. The burner was the same gun-type oil burner which was used in the conversion unit. Hence, any differences in performance of the two furnace installations could be attributed to the differences in the furnace and not to the differences in the type of oil burner used. The fan and furnace were built into a compact unit which was housed in an insulated casing. The values for the heating surfaces of the two furnaces are listed in Table 1, from which it may be noted that the oil-burning furnace

*Research Professor, Engineering Experiment Station, University of Illinois.

**Special Research Associate, Engineering Experiment Station, University of Illinois.

[1]University of Illinois, Engineering Experiment Station, Bulletin 266 by A. P. Kratz and S. Konzo, 1934.

[2]Automatic Controls for Forced-Air Heating Systems, by S. Konzo and A. F. Hubbard, A. S. H. V. E. TRANSACTIONS, Vol. 40, 1934, pp. 37 to 54.

[3]Fuel Saving Resulting from the Use of Storm Windows and Doors, by A. P. Kratz and S. Konzo, A. S. H. V. E., JOURNAL SECTION, *Heating, Piping and Air Conditioning*, Dec. 1935, pp. 595-599.

For presentation at the 43rd Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, St. Louis, Mo., January, 1937.

Table 1—Areas and Dimensions of Furnaces

Heating Surface sq ft	Conversion Unit	Oil-Burning Furnace
Ashpit	11.38	....
Firepot	8.10	....
Tubes	....	59.5
Combustion Section	18.87	23.6
Radiator	31.93	19.0
Total, sq ft	70.28	102.1
Grate Area, sq ft	2.88	....
Refractory top section inside dimension, in	Diameter 17.0	14.5 x 26.5
Combustion space,[a] cu ft	2.36	2.56

[a]The combustion space is regarded as that space enclosed within the refractory bricks.

had approximately 45 per cent greater heating surface than did the conversion unit.

The fuel oil burned was a No. 3 grade furnace oil having a specific gravity of approximately 36 deg Baumé and a heating value of approximately 19,750 Btu per lb.

The control[4] of the heating plant was accomplished by means of a room thermostat operating to start and stop the oil burner and the circulating fan. This room thermostat was used in conjunction with two bonnet thermostats, one of the latter operated to stop the burner when the bonnet temperature exceeded a predetermined value, and the other operated to stop the fan when the bonnet temperature became less than a predetermined value. The room thermostat was located on an inside wall of the dining room at a height of 60 in. from the floor, and was adjusted to maintain an air temperature of approximately 71 F at this level in all of the rooms of the Residence.

[4]See Control type IV described in reference item 2.

Method of Conducting Tests

Tests Under Continuous Operation

In order to determine the capacity at the bonnet and the thermal efficiency of the furnaces for various conditions of operation, tests were made under conditions of thermal equilibrium with both the furnace and the fan operating continuously. In these tests, the temperature of the inlet air was maintained at approximately 70 F, and the quantity of circulating air, the rate of oil input, the draft in the combustion chamber, and the amount of air required for combustion were maintained at predetermined values during the two-hour test period. These tests, which corresponded to the usual laboratory tests for the determination of the heat output of a heating unit, provided data for the heating unit only, without reference to the structure in which it was placed.

The quantities referred to as *capacity, combustion rate, bonnet efficiency,* and *overall house efficiency* are defined by the given equations:

$$\text{Capacity, Btu per hour put into air} = W \times 0.24 \times (T_b - T_1)$$

$$\text{Heat liberated in furnace, Btu per hour} = C \times H$$

$$\text{Bonnet efficiency, per cent} = \frac{W \times 0.24\,(T_b - T_1) \times 100}{C \times H}$$

$$\text{Overall house efficiency, per cent} = \frac{[(C \times H) - \text{Flue loss up chimney}]\ 100}{C \times H}$$

in which:

W = weight of air flowing in system per hour, lb.
0.24 = mean specific heat of air.
C = combustion rate, pounds of oil burned per hour.
H = calorific value of oil, Btu per pound.
T_1 = temperature of air at inlet to furnace, F.
T_b = temperature of air at furnace bonnet, corrected for radiation, F.

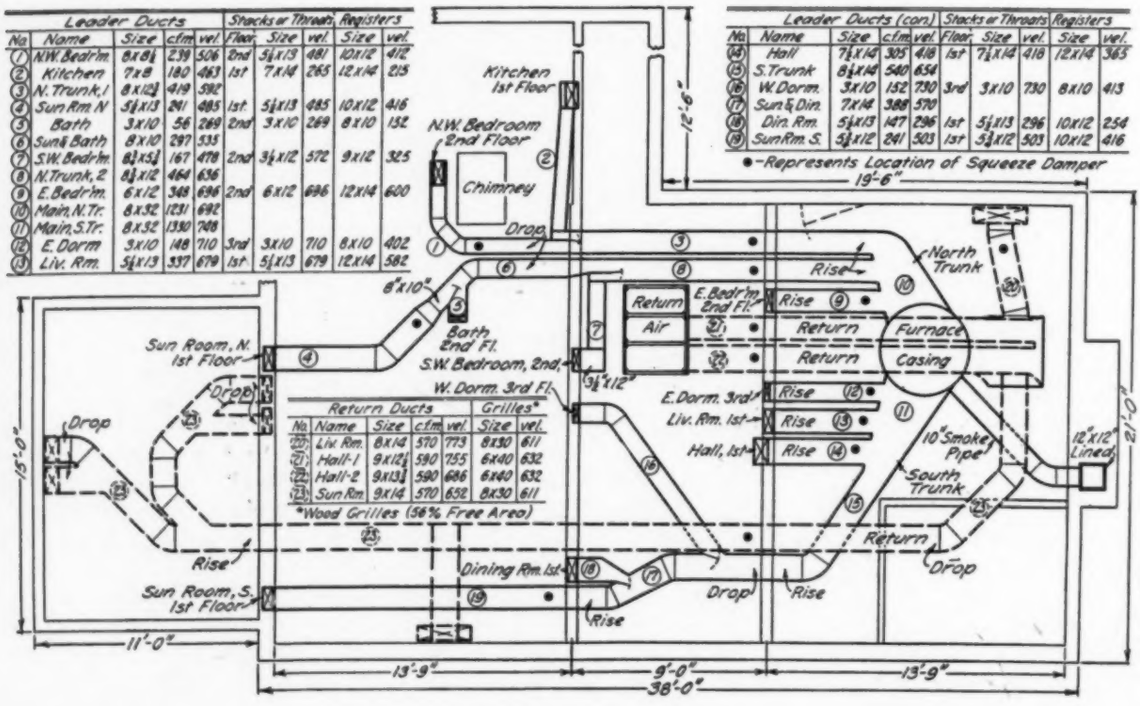

Leader Ducts
No. Name Size cfm vel. Floor Size vel. Size vel.
1 NW. Bedrm. 8x8½ 239 506 2nd 5½x13 481 10x12 412
2 Kitchen 7x8 180 463 1st 7x14 265 12x14 215
3 N. Trunk, 1 8x12½ 419 592
4 Sun Rm. N 5½x13 241 485 1st 5½x13 485 10x12 416
5 Bath 3x10 56 269 2nd 3x10 269 8x10 132
6 Sun & Bath 8x10 297 535
7 S.W. Bedrm. 8½x5½ 167 478 2nd 3½x12 572 9x12 325
8 N. Trunk, 2 8½x12 464 636
9 E. Bedrm. 6x12 348 696 2nd 6x12 696 12x14 600
10 Main, N. Tr. 8x32 1231 692
11 Main, S. Tr. 8x32 1330 748
12 E. Dorm 3x10 148 710 3rd 3x10 710 8x10 402
13 Liv. Rm. 5½x13 337 679 1st 5½x13 679 12x14 582
Leader Ducts (con.) Stacks or Throats Registers
14 Hall 7½x14 305 418 1st 7½x14 418 12x14 365
15 S. Trunk 8½x14 540 654
16 W. Dorm. 3x10 152 730 3rd 3x10 730 8x10 413
17 Sun & Din. 7x14 388 570
18 Din. Rm. 5½x13 147 296 1st 5½x13 296 10x12 254
19 Sun Rm. S. 5½x12 241 503 1st 5½x12 503 10x12 416
•-Represents Location of Squeeze Damper
Return Ducts Grilles*
20 Liv. Rm. 8x14 570 773 8x30 611
21 Hall-1 9x12½ 590 755 6x40 632
22 Hall-2 9x13½ 590 686 6x40 632
23 Sun Rm. 9x14 570 652 8x30 611
*Wood Grilles (58% Free Area)
Kitchen 1st Floor
N.W. Bedroom 2nd Floor
Chimney
Drop
8"x10"
Bath End Fl.
S.W. Bedroom, 2nd.
W. Dorm. 3rd Fl.
3½"x12"
E. Bedrm. End Fl.
E. Dorm. 3rd
Liv. Rm. 1st
Hall, 1st
Return Air
Rise
Return
Furnace Casing
North Trunk
South Trunk
10" Smoke Pipe
12"x12" Lined
Sun Room, N. 1st Floor
Sun Room, S. 1st Floor
Dining Rm. 1st
12'-6"
19'-6"
15'-0"
11'-0"
13'-9"
9'-0"
13'-9"
38'-0"
21'-0"

Fig. 2—Plan of duct system in basement

Tests Under Service Conditions

The tests made under service conditions differed from the tests made under continuous operation in that the operation of the burner and fan was automatically controlled to maintain a temperature of 71 F in all the rooms of the house rather than to maintain a constant capacity at the furnace bonnet. Therefore, in these tests the operation of the burner and fan was intermittent in character and not continuous, and the test periods were 24 hours in length instead of 2 hours.

Observations of fuel consumption, flue gas analyses, power input to the fan motor and burner motor, flue gas temperatures, temperatures of the air in the ducts and at the registers, and room temperatures were made daily at 7:00 a.m., 11:00 a.m., 4:00 p.m., and 10:00 p.m. The total times of operation of the fan and of the burner for a 24-hour period were obtained by means of self-starting, electric clocks placed in the electrical circuits of the motors. In addition, continuous records of temperatures and CO_2, such as shown in the typical records in Fig. 5, were obtained for each 24-hour period.

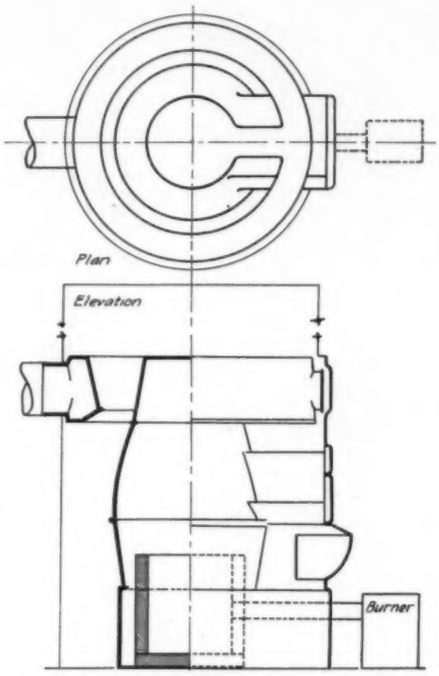


Fig. 3—Diagram of conversion oil-burning unit

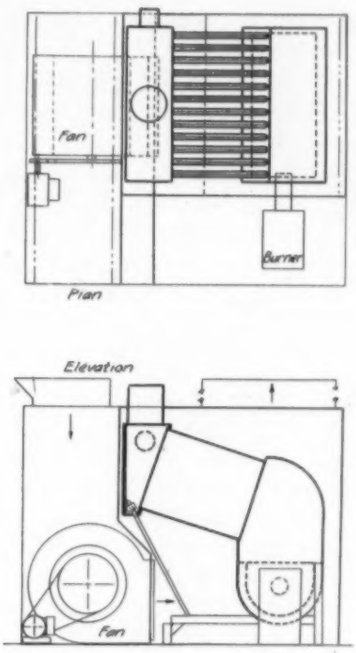


Fig. 4—Diagram of oil-burning furnace

Results of Tests Under Continuous Operation

Preliminary Statement

No attempt was made to determine virtual capacities or efficiencies of the plant with intermittent operation of the fan. Average temperatures and air weights would be meaningless unless the various readings were weighted in some way proportional to the length of *on* and *off* periods. Periods during which temperatures were increasing or decreasing while air weights remained constant complicated the situation, and made it impossible to determine any proportionality factor based on time. Furthermore, all quantities were not involved to the first power alone, and the average of a number of instantaneous results involving multiplication, division, addition, and subtraction indiscriminately is not numerically equal to the result obtained by the same form of calculation applied to the averages of the several factors, particularly when these factors are varying from zero to a maximum. Hence the actual efficiency and capacity of the furnace on intermittent fan operation are indeterminate, and a statement of such quantities based on arbitrary approximations would be meaningless. The performance of the plant was therefore studied under conditions of continuous fan operation.

In the case of a gravity warm-air furnace, in which a unique relationship exists between the combustion rate, the air volume, and the register temperature, the capacity will be a definite value for any given furnace installation if the combustion rate alone is specified. However, in the case of a forced-air furnace system, no such definite relationship exists between combustion rate and air volume, and as a consequence the capacity is dependent on more than the combustion rate alone. These studies of performance characteristics under conditions of continuous operation were, therefore, undertaken to obtain the relationships existing among some of the factors that determine the capacity of oil-burning furnaces. In general, the capacity and efficiency of oil-burning furnaces are dependent upon seven factors, which may be grouped into two classifications as shown in Table 2.

It may be noted from Table 2 that for any given installation of burner and furnace, items 1, 5, and 6 are fixed, and items 2, 3, 4, and 7 are independently variable. However, in all of the tests reported in this paper, the draft in the combustion chamber (item 4) was maintained

Table 2—Factors Affecting Capacity and Efficiency of an Oil-Burning, Warm-Air Furnace

I. Combustion characteristics
   1. Type of burner
   2. Rate of oil input
   3. Percentage of CO_2 in flue gas
   4. Conditions of draft in combustion chamber

II. Furnace characteristics
   5. Amount and location of heating surfaces
   6. Size and shape of combustion space
   7. Quantity of air circulated

by means of an automatic draft regulating damper at a value of 0.02 in. of water, which was sufficient to insure the positive removal of the flue gases. Hence, the studies on furnace performance consisted of tests in which the rate of oil input, the percentage of CO_2 in the flue gas, and the quantity of air circulated were independently varied in magnitude.

Variations in Air Quantity

The results obtained from the conversion unit are shown in Fig. 6. For these tests, the CO_2 in the flue gas was maintained constant at a value of 9.5 per cent, and the effect of varying the quantity of air circulated over the heating surfaces of the furnace was studied. The results shown are typical and are similar in nature to those obtained from tests on the oil-burning furnace installation made under similar conditions of operation. The full lines in Fig. 6 represent results obtained with constant rates of oil input to the furnace. It may be noted that for a given rate of oil input, both the capacity and efficiency of the furnace increased as the quantity of air circulated over the heating surfaces was increased. For example, at a 9.66-lb oil input rate, the capacity was increased from 120,000 Btu per hour to 140,000 Btu per hour when the air quantity was increased from approximately 1380 cfm to 2240 cfm. This represented an increase in capacity of approximately 17 per cent for an increase in air quantity of approximately 62 per cent. The corresponding increase in bonnet efficiency under these conditions was from 63 per cent to 74 per cent.

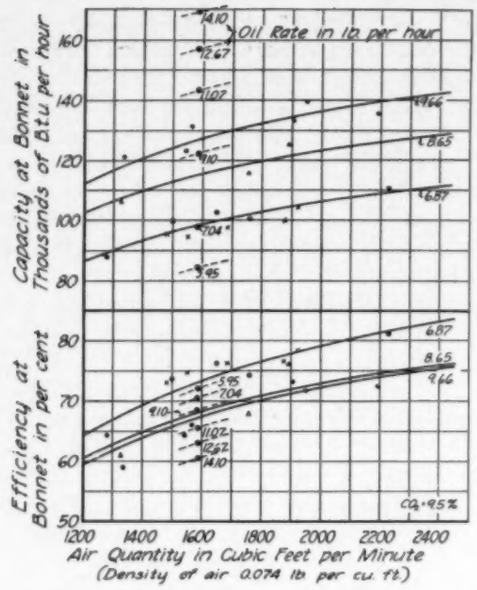


Fig. 6—Performance curves of conversion unit in forced-air heating system

It may also be noted from Fig. 6 that the increase in capacity for a given increase in air quantity became smaller as the air quantity was increased. For example, an increase in air quantity from 1400 cfm to 1600 cfm resulted in an increase in capacity of 6500 Btu per hour; whereas an increase in air quantity from 2000 cfm to 2200 cfm resulted in an increase in capacity of only 2500 Btu per hour. It is apparent from these tests that in order to facilitate the transfer of heat from the heated surfaces to the circulating air, an adequate circulation of air over the heating surfaces should be provided.

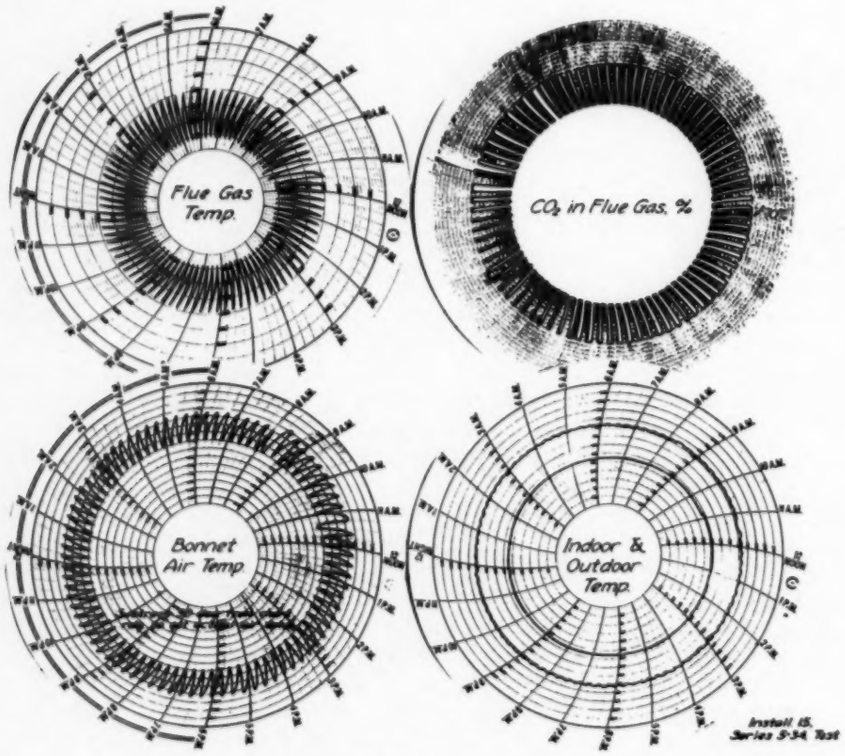


Fig. 5—Typical records showing operation with conversion oil furnace used with forced-air heating system in Research Residence

Variations in Oil Input Rate

The performance curves in Fig. 6 show also that for a constant quantity of air circulated, the capacity and efficiency of the furnace are dependent upon the rate of oil input to the burner. In order to show more clearly the relationship between oil input and capacity, the values for an air quantity of 1675 cfm shown in Fig. 6 have been plotted in Fig. 7. Similar curves for the oil-burning unit are also given. The broken lines represent results

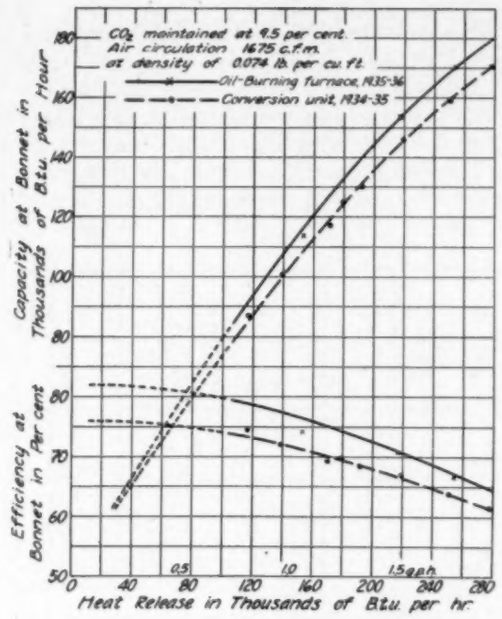

CO_2 maintained at 9.5 per cent.
Air circulation 1675 c.f.m.
at density of 0.074 lb. per cu. ft.
Oil-Burning furnace, 1935-36
Conversion unit, 1934-35
Capacity at Bonnet in Thousands of Btu. per Hour
Efficiency at Bonnet in Per cent
0.5
1.0
1.5 g.p.h.
Heat Release in Thousands of Btu. per hr.

Fig. 7—Performance curves of oil furnaces in Research Residence

obtained with the conversion unit, and the full lines represent results obtained with the oil-burning furnace.

It may be noted for both furnace units that the capacity at the bonnet increased as the rate of oil input, or its equivalent which is the rate of heat release in the furnace, was increased. In the case of the conversion unit, an increase in the heat release of from 120,000 Btu per hour to 240,000 Btu per hour, or a difference of 120,000 Btu per hour, was accompanied by an increase in capacity of from 87,500 Btu per hour to 155,500 Btu per hour, or a difference of 68,000 Btu per hour.

In any given furnace installation, in which a constant value of CO_2 was being maintained, an increase in the amount of heat release in the furnace resulted in higher temperatures of the flue gas and hence in larger flue gas losses per pound of fuel. This condition is reflected in the efficiency curves of Fig. 7, from which it may be observed that the furnace efficiency decreased as the rate of heat release was increased. The tests made under actual service conditions, which are discussed in a later section, also tended to confirm the conclusion that the most economical utilization of fuel in a given installation would be obtained with small rates of heat release in the furnace.

A comparison of the results from the conversion unit and oil-burning furnace, as shown in Fig. 7, indicated that, for a given rate of heat release in the furnace, the greater amount of heating surface of the oil-burning unit resulted in a greater amount of heat being transmitted from the furnace gases and absorbed by the air circulated. This conclusion was also confirmed by the tests made under actual service conditions.

The efficiency curves in Fig. 7 also show that for a furnace having a given amount of heating surface the best rate of oil input as defined by the heat release occurs at a value too low to be used as a practical basis for the design of oil-burning furnaces.

Variation in CO_2 in Flue Gas

The performance curves in Fig. 8 indicate that for a constant quantity of air circulated and a fixed rate of oil input to the furnace, the capacity and efficiency of the heating unit were also affected by the combustion characteristics, as indicated by the percentage of CO_2 in the flue gas. Adjustments in the fuel-air ratio were made by means of the adjustable opening in the air-inlet to the burner, and variations in the CO_2 content in the flue gas from 5½ per cent to 11½ per cent could be obtained. In no case was there any indication of incomplete combustion of the fuel.

The increase in capacity and efficiency brought about by an increase in the CO_2 content in the flue gas was not marked. For example, the efficiency curves for the 12.84-lb oil input rate indicate that the efficiency was increased from 61 per cent to 67.5 per cent when the percentage of CO_2 in the flue gas was changed from 6 per cent to 12 per cent. In other words, for each increase in the CO_2 content of one per cent, there was obtained an increase in bonnet efficiency of approximately one per cent.

However, it should be recognized that these results were obtained with a furnace in which the temperature of the flue gas at the outlet of the radiator was quite low and did not exceed approximately 500 F. In the case of furnaces which are not provided with sufficient effective heating surface, and which are fired at such a high rate of oil input that the temperature of the flue gas at the outlet exceeds approximately 500 F, any increase in the CO_2 content of the flue gas will be accompanied by much larger increases in furnace efficiency.

The stack-loss curves shown in Fig. 9[5], serve to ex-

[5]Curve reproduced from U. S. Dept. of Agriculture Technical Bulletin No. 109 entitled, A Study of the Oil Burner as Applied to Domestic Heating, by Arthur H. Senner, July, 1929.

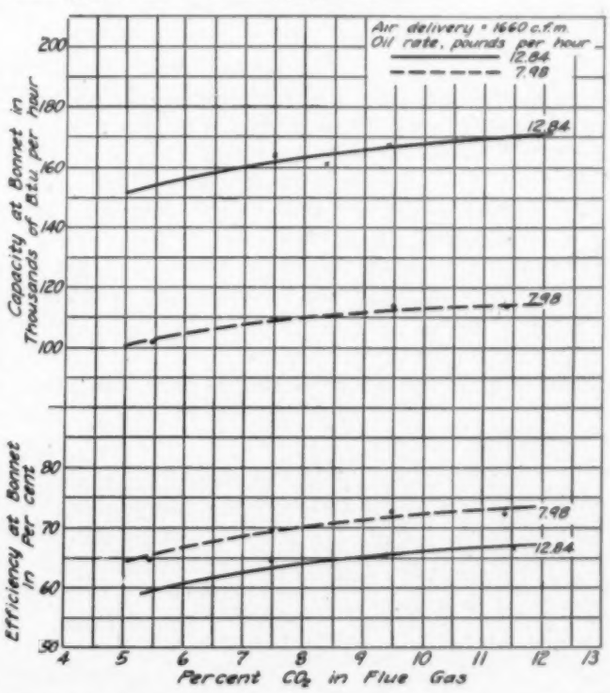

Air delivery = 1660 c.f.m.
Oil rate, pounds per hour
12.84
7.98
Capacity at Bonnet in Thousands of Btu. per Hour
Efficiency at Bonnet in Per cent
Percent CO_2 in Flue Gas

Fig. 8—Performance of an oil-burning furnace with various percentages of CO_2 in the flue gas

Research Residence installation 16, forced-air system. Furnace designed for oil combustion using gun burner. Tests conducted with continuous operation of burner and fan. Season 1935-36.

plain these conditions. For instance, for low values of the flue gas temperature, the relative change in the stack loss will be small even for fairly large changes in the CO_2 content of the flue gas. In other words, if oil-burning furnaces are provided with sufficient effective heating surface for a given rate of oil input, so that the leaving flue gas temperature will be low, then the unit may be expected to perform satisfactorily under diverse conditions of installation in the field, even with fairly wide deviations in the adjustment of the fuel-air ratio of the oil burner.

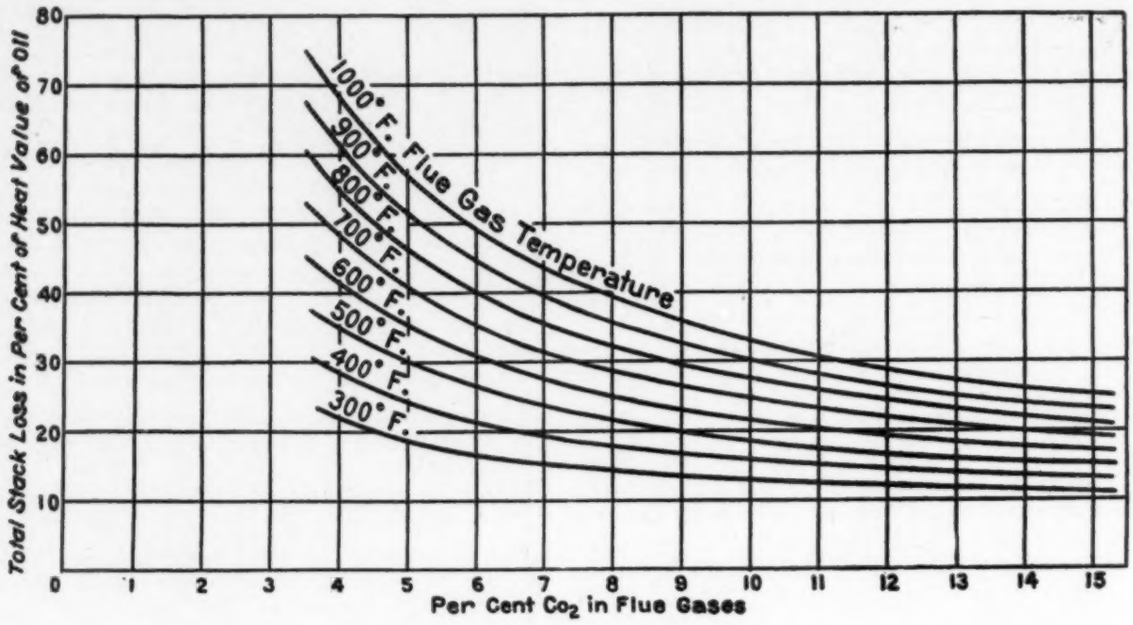


Fig. 9—Stack-loss curves for combustion of domestic oil-burner distillates.

These tests which were made under conditions of continuous operation have indicated that considerable differences in the capacity of oil-burning furnaces may be expected with variations in operating conditions. However, since capacity alone is not an index of performance under intermittent service, and since the tests were based on the maintenance of equilibrium conditions, which are seldom met with in actual service conditions these tests were supplemented with tests made under conditions of actual service.

Results of Tests Under Actual Service Conditions

Preliminary Statement

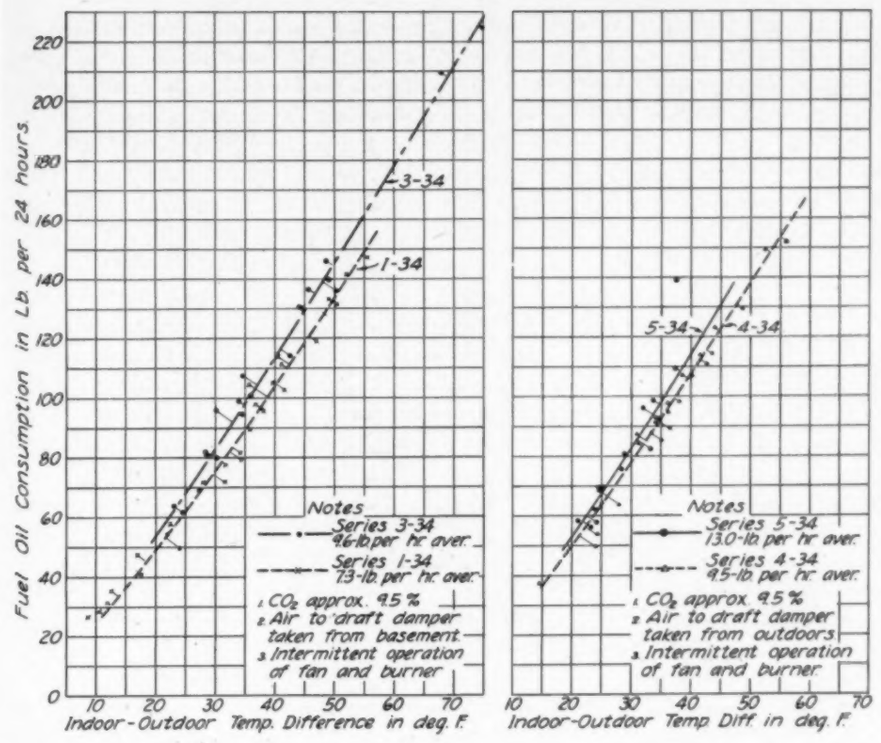
It is evident from the preceding discussion that the results obtained from oil-burning furnaces which are operated under actual service conditions should be dependent to a great extent upon the values which are maintained for the CO_2 content in the flue gas, for the oil input rate, and for the quantity of air circulated. In the case of the air quantity, in order to maintain comparable conditions with previous tests, the speed of the fan was adjusted so that approximately 1675 cfm delivery was obtained during the on-period of the fan. During the off-period of the fan a slight *gravity* action took place and a greatly decreased air quantity was circulated. With the exception of the series of tests for which the CO_2 content in the flue gas was maintained at 11.5 per cent, all of the tests were made with the CO_2 maintained at 9.5 per cent. For one series of tests the rate of oil input to the furnace was adjusted from a minimum value of 7.3-lb per hour to a maximum value of 13.0-lb per hour. However, for those tests which were made to study the comparative performance of the conversion unit and the oil-burning furnace the rate of oil input was adjusted to 13.0-lb per hour.

Variation in Rate of Oil Input

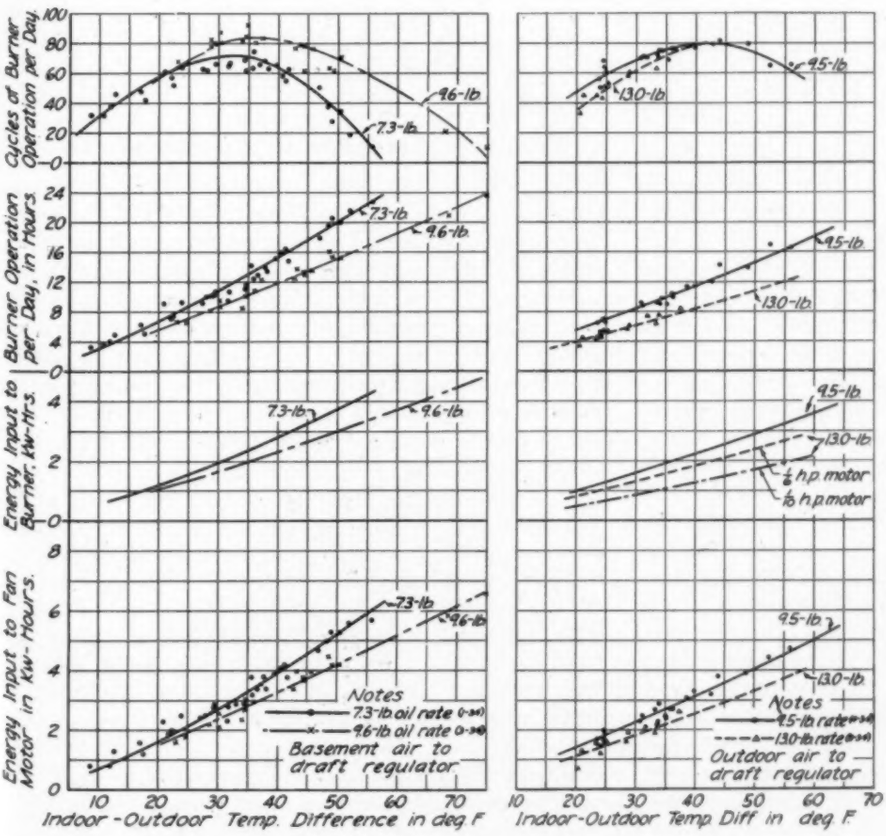
An extensive series of tests was conducted with a wide range of oil input rates that ranged from a minimum of 7.3-lb per hour to a maximum of 13.0-lb per hour. The heat supplied by the furnace when the burner was adjusted to maintain a 7.3-lb oil rate was not quite sufficient to offset the heat loss from the house during zero-degree weather, but was sufficient to supply the heat required during average weather conditions. The heat supplied by the furnace when the 13.0-lb rate was maintained was adequate to heat the house during the most severe weather conditions.

The weight of fuel oil required for a 24-hour period to maintain the temperature of the house at 71 F was plotted against the difference in temperature between indoors and outdoors, as shown in Figs. 10a and 10b. The curves presented in Fig. 10a are for two rates of oil input, 7.3-lb and 9.6-lb per hour; while the curves presented in Fig. 10b are for rates of 9.5-lb and 13.0-lb per hour.

Although some of the points representing the daily test results deviate somewhat from the average curve drawn through the points, because of the influences of wind and sun which cannot be shown on a curve in which the abscissa is the temperature difference alone, the curves represent the general trend of the points with a


Fuel Oil Consumption in Lb. per 24 hours
3-34
1-34
5-34
4-34
Notes
Series 3-34 9.6-lb per hr. aver.
Series 1-34 7.3-lb per hr. aver.
1 CO2 approx. 9.5 %
2 Air to draft damper taken from basement
3 Intermittent operation of fan and burner
Series 5-34 13.0-lb per hr. aver.
Series 4-34 9.5-lb per hr. aver.
2 Air to draft damper taken from outdoors
Indoor-Outdoor Temp. Difference in deg. F.
Indoor-Outdoor Temp Diff. in deg. F.

Figs. 10a *(left)* and 10b *(right)*—Daily fuel consumption curves for various rates of oil input into conversion oil furnace with forced-air heating system. Season 1934-35, Inst. 15



Figs. 11a *(left)* and 11b *(right)*—Performance data for burner and fan operation in Research Residence. Conversion oil furnace with forced-air heating system. Season 1934-35. Inst. 15

reasonable degree of accuracy. The curves show that when a constant value of CO_2 in the flue gas was maintained, the fuel consumption increased as the rate of oil input was increased. For instance, it may be noted from Fig. 10b that the fuel requirements for a day in which the temperature difference between indoors and outdoors was 33 F were 88-lb and 94-lb for oil input rates of 9.5-lb per hour and 13.0-lb per hour, respectively. The increase in this case was of the order of 6 per cent. This indicates that the operation of the burner for relatively short periods, during which a high rate of combustion was maintained, was not as conducive towards fuel economy as the operation of the burner for longer periods, during which a lower rate of combustion was maintained. In the former case the flue losses during the periods of burner operation, and also the losses due to the heat carried up the chimney during the off-periods of the burner, were greater than in the latter case on account of the higher temperatures of the flue gas. These statements would have to be modified, however, if there are any cases in which conditions might arise whereby the combustion process can be maintained better with high rates of oil input than with low rates.

The changes in the rate of oil input to the furnace were also reflected in the operation of the fan and burner units in the forced-air heating system, as shown by the data in Figs. 11a and 11b. The top set of curves in Figs. 11a and 11b shows, for the same series of tests whose results were shown in Figs. 10a and 10b, the frequency of burner operation as represented by the number of cycles per 24 hours. For a given rate of oil input it may be noted that in mild weather the frequency of operation of the burner increased as the temperature difference between indoors and outdoors increased. For larger values of temperature differences the burner continued in operation for longer periods and the fre-

quency of the operating periods decreased. Finally, when the outdoor weather conditions were such that the heat developed in the furnace was just sufficient to offset the heat loss from the house, the burner operated continuously and the number of cycles per 24 hours became unity.

It may be noted from the second set of curves in Figs. 11a and 11b that the increase in the total time of operation of the burner was practically proportional to the increase in temperature difference between indoors and outdoors. Also, for a given outdoor temperature condition an increase in the rate of oil input was accompanied by a decrease in the total time of burner operation. Furthermore, the decrease in the total time of burner operation was in turn accompanied by a decrease in the electrical energy input to the burner motor, as shown by the third set of curves. It may be observed from Fig. 11b that the substitution of a more efficient motor on the burner unit resulted in more economical use of electric current. It is also apparent that the electrical input to the burner motor, which included the energy required for the spark ignition process, was sufficiently large to be considered as an important item in determining the overall cost of operation of the heating plant.

With the method of thermostatic control used in these tests, the times at which the fan operated practically coincided with the times at which the burner operated, or the frequency of operation was nearly the same for both fan and burner. The total time of fan operation was in most cases slightly greater than the total time of burner operation, but the differences were so small that for all practical purposes the data presented in the second set of curves in Figs. 11a and 11b apply equally well to the fan and the burner. The electrical input to the fan motor as shown by the bottom set of curves in Figs. 11a and 11b was smaller for the higher rates of oil input.

A comparison of total operating costs for an *average* heating day are of interest. For Urbana, Illinois, the average outdoor temperature during the heating season is 38 F. Hence for an indoor temperature of 71 F, the value of the average temperature difference between indoors and outdoors is 33 F. The comparisons based on this temperature difference may be regarded as indicative of the results to be secured from the entire heating season. For a day in which the indoor-outdoor temperature difference was 33 F the combined electrical energy inputs to the fan motor and burner motor were 4.4 kwhr and 3.6 kwhr for oil input rates of 9.5-lb and 13.0-lb per hour respectively. That is, the increase in fuel oil consumption, amounting to 6 lb of oil per 24 hours which accompanied the use of the higher rate of oil input to the furnace, was partly offset by a decrease in consumption of electrical energy amounting to 0.8 kwhr. Based on unit costs of 7 cents per gallon for fuel oil and of 3.1 cents per kwhr for electrical energy, the increase in fuel cost amounting to 5.7 cents per day and the decrease in electrical cost amounting to 2.5 cents per day resulted in a net increase in cost of 3.2 cents per day. For conditions under which the unit electrical cost is much higher than 3.1 cents per kwhr, the net increase in cost might become negligible.

It is apparent from this study that seasonal operating costs of an oil-fired, forced-air heating system based only on the cost of fuel may be misleading, and that the total cost of operation which includes electrical costs should be considered. In most installations the minimum capacity limitations of the burner and the desirability of maintaining ample reserve capacity for sudden load demands make it necessary to provide an oil input rate that is somewhat in excess of the maximum heating demands. However, it may be concluded from these tests that from the standpoint of total operating cost the most economical operation would be obtained with the use of the minimum rate of oil input that is feasible for the installation.

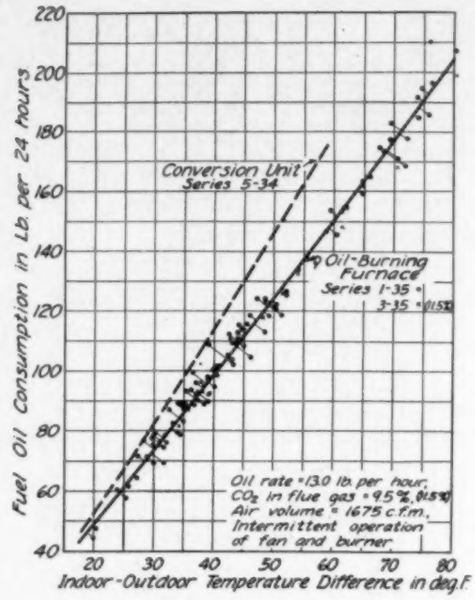

Fuel Oil Consumption in Lb per 24 hours
Indoor-Outdoor Temperature Difference in deg.F
Conversion Unit
Series 5-34
Oil-Burning Furnace
Series 1-35 and 3-35
Oil rate = 13.0 lb per hour,
CO2 in flue gas = 9.5%,
Air volume = 1675 c.f.m.,
Intermittent operation of fan and burner

Fig. 12—Fuel consumption curves for two oil furnaces

Comparison of Conversion and Oil-Burning Units

The tests which were made to determine the comparative performance characteristics of the conversion unit and the oil-burning furnace under actual service conditions were conducted under identical conditions of operation. The results obtained for an oil input rate of 13.0-lb per hour with the conversion unit were presented in Figs. 10b and 11b and have been transferred to Figs. 12 and 13 for purposes of comparison with the results obtained with the oil-burning furnace. The curves representing the results for the latter furnace are shown as full lines.

It may be noted from the fuel consumption curves shown in Fig. 12 that the fuel requirements, for a day in which the indoor-outdoor temperature difference was 33 F, were 94-lb for the conversion unit and 82.5-lb for the oil-burning furnace. Thus the fuel requirements for an average day were approximately 14 per cent greater for the conversion unit than they were for the oil-burning furnace. For an indoor-outdoor temperature difference of 55 F the difference was greater, and amounted to approximately 19 per cent.

Slight differences in operating characteristics were also obtained, as are shown by the curves in Fig. 13, for burner cycles, burner operation, burner motor input, and fan motor input. Very little difference may be observed in the number of cycles of burner operation per day for the two installations. However, both the num-

ber of hours of burner operation and the electrical energy input to the burner motor were greater for the conversion unit than for the oil-burning furnace. This could be accounted for by the fact that although the rate of oil input was the same in the two installations, the total fuel consumption was greater for the conversion unit than for the oil-burning furnace and hence the hours of burner operation were also greater.

It may be observed that although the total time of fan operation per day was approximately 12 per cent less for the oil-burning furnace than for the conversion unit, the total electrical input to the fan was approximately 8 per cent greater. This difference can be accounted for by the fact that, due to the greater resistance to air flow in the case of the oil-burning furnace and also due to slight differences in motor characteristics, the rate of electrical input to the fan motor for the oil-burning furnace was approximately 25 per cent greater than that to the fan motor for the conversion unit.

For a day in which the temperature difference between indoors and outdoors was 33 F, the combined electrical energy inputs to the fan and burner motors were 3.1 kwhr for the conversion unit and 2.9 kwhr for the oil-burning furnace, or a net difference of 0.2 kwhr per day. The difference was greater for days having greater heat demand. The operation of the oil-burning furnace resulted, therefore, in a net reduction in fuel oil of 11.5 lb and a net reduction in electrical energy of 0.2 kwhr per day. Based on unit costs of 7 cents per gallon for fuel oil and 3.1 cents per kwhr for electrical energy, these reductions were equivalent to 10.9 cents per day for fuel and 0.6 cents per day for electrical energy, or a total of 11.5 cents per day. For an average heating season consisting of 210 days this is equivalent to a difference in net operating costs of approximately $24. It may be concluded from these tests that under identical conditions of operation, the best economy was secured with the furnace which was equipped with ample heating surface and which was designed specifically for oil burning.

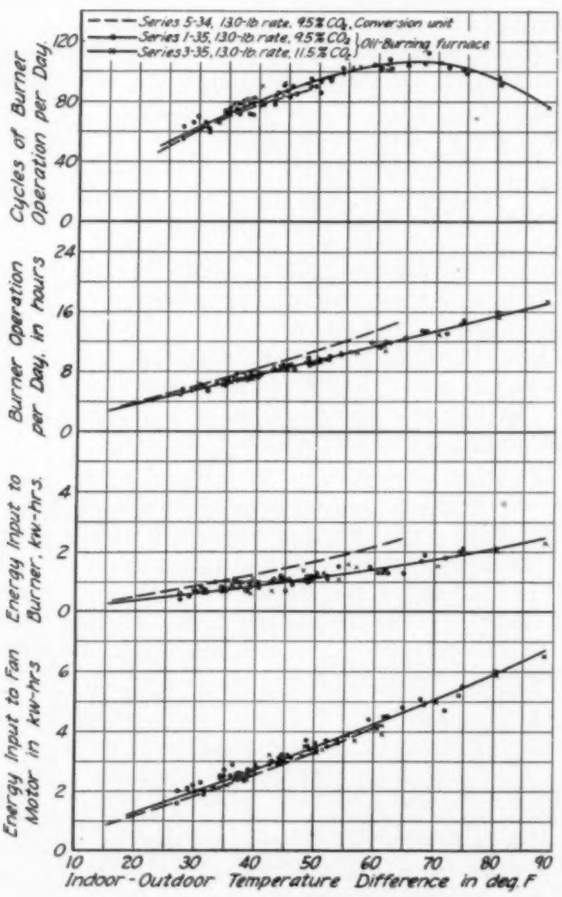

Series 5-34, 13.0-lb rate, 9.5% CO_2, Conversion unit
Series 1-35, 13.0-lb rate, 9.5% CO_2 } Oil-Burning furnace
Series 3-35, 13.0-lb rate, 11.5% CO_2 }
Cycles of Burner Operation per Day
Burner Operation per Day, in hours
Energy Input to Burner, kw-hrs.
Energy Input to Fan Motor in kw-hrs
Indoor - Outdoor Temperature Difference in deg F

Fig. 13—Performance data for burner and fan operation in Research Residence, oil furnace, forced-air heating system. Season 1935-36, Inst. 16

Variations in CO_2 in Flue Gas

In order to determine the operating characteristics of the oil-burning furnace when the fuel was burned under the best attainable combustion conditions, the air inlet to the burner was adjusted until a value of 11.5 per cent CO_2 in the flue gas was obtained. It was not possible to increase the CO_2 content much beyond this value without obtaining some indication of unburned combustibles. Otherwise, the operating conditions were maintained the same as in the previous tests; namely with 1675 cfm air circulated, 13.0-lb oil rate, and 0.02 in. draft in the combustion chamber. The results obtained from this test are shown in Figs. 12 and 13 in which the points are designated as belonging to Series 3-35. In general, no appreciable difference, either in fuel consumption or plant operation, was obtained when the CO_2 content in the flue gas was increased from 9.5 per cent to 11.5 per cent. However, when the heat demands of the house were large, there was a slight tendency towards an improvement in conditions with the higher CO_2 content. These results are in substantial agreement with those obtained from the tests made under conditions of continuous operation, as shown in Fig. 8. For example, for an oil input rate of 12.84 lb per hour, the increase in bonnet efficiency was approximately 1.5 per cent when the CO_2 content was increased from 9.5 per cent to 11.5 per cent. For all practical purposes the results obtained with the two conditions of combustion may be regarded as identical.

These results serve to emphasize the statement previously made that an oil-burning furnace which is provided with sufficient effective heating surface should perform satisfactorily notwithstanding fairly wide deviations in the CO_2 content of the flue gas.

Overall House Efficiency

In order to compare the fuel consumptions with oil and anthracite, the fuel quantities shown in Fig. 12 were reduced to terms of heat input to the furnace, in millions of Btu per 24 hours, and were plotted as shown in Fig. 14. The results for the conversion unit (Curve No. 1) and for the oil-burning furnace (Curve No. 2) were obtained with an oil input rate of 13.0-lb per hour, a combustion condition of 9.5 per cent CO_2 and an air circulation of 1675 cfm. It should be noted that these tests were based on intermittent operation of the fan and oil burner, whereas the tests on the hand-fired coal furnace (Curve No. 3) were based on the maintenance of continuous combustion under which conditions the automatic controls varied the combustion rate so that it approximately corresponded with the heating demands

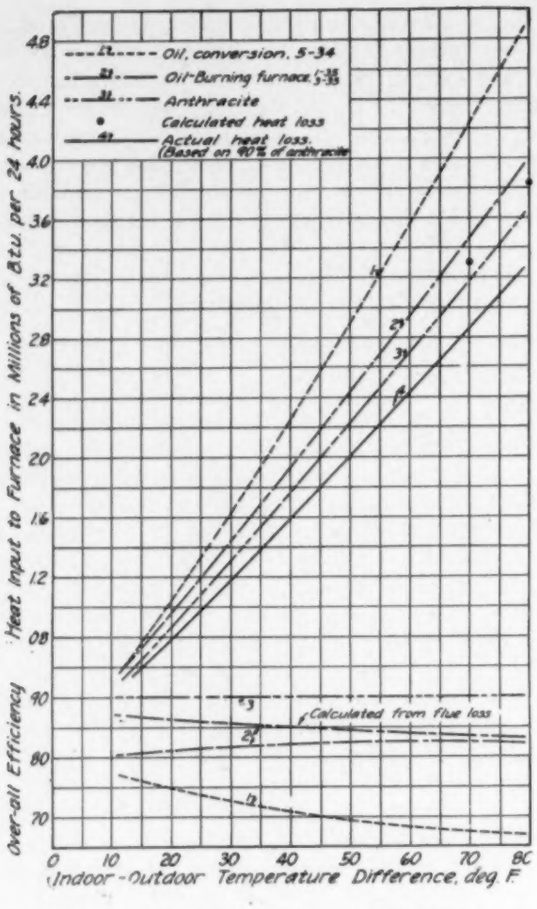

Oil, conversion, 5-34
Oil-Burning furnace, 5-35
Anthracite
Calculated heat loss
Actual heat loss, (Based on 40% of anthracite
Heat Input to Furnace in Millions of Btu per 24 hours
Over-all Efficiency
Calculated from flue loss
Indoor-Outdoor Temperature Difference, deg. F.

Fig. 14—Heat inputs to Research Residence

of the house. In all three cases the operation of the heating plant was controlled by means of sensitive thermostatic controls.

From analyses of the flue gases when anthracite was used as a fuel, the heat lost in the gases escaping from the chimney, which represented heat furnished by the fuel that was not ultimately available for heating the house, was determined as approximately 10 per cent of the total heat input to the furnace. The actual heat loss from the house (Curve No. 4) was then derived from the experimental results for heat input obtained with anthracite as a fuel (Curve No. 3). By using these derived values of the actual heat loss from the house in connection with the fuel consumption curves for oil, the overall house efficiency could be calculated for the cases in which oil was used as a fuel in the conversion unit and in the oil-burning furnace. These curves representing overall house efficiency are shown in the lower part of Fig. 14. It may be noted that the values of overall house efficiency determined indirectly in this manner for the oil-burning furnace agreed reasonably well with the calculated values of overall house efficiency determined directly from an analysis of the flue gas losses during the periods of burner operation.

For the same weather conditions, the values of the heat input were less and the values of the overall house efficiency were greater for anthracite than for oil. The most obvious explanation for this difference is that the combustion efficiency for oil combustion was considerably less than that for anthracite. This most obvious explanation, however, was not satisfactory since there was no reason to believe that a material difference existed either in the combustion efficiency, or that the flue gas losses were greater in the one case than in the other. In order to make an independent analysis of the factors affecting the utilization of heat by the furnace, the weight of the products of combustion and the flue gas losses were calculated from the flue gas analyses and the temperatures of the flue gas, observations of which were made under conditions of continuous operation of the burner and fan. These results are shown in Fig. 15a plotted against the heat input to the furnace.

The flue loss for any fuel may be considered as a composite value which is dependent on both the temperature and the weight of the flue gas. A comparison of the curves representing flue gas temperature in Fig. 15a shows that the flue gas temperatures were lower for oil, when it was burned in the oil burning furnace, than for anthracite. This indicates that the flue gas temperature alone is not a reliable index of combustion efficiency when comparing different fuels. The products of combustion may be considered as being composed of dry gas and water vapor. The curves in Fig. 15a indicate that the weight of the dry gas was approximately the same for oil and for anthracite, but that the weight of water vapor was greater for oil than for anthracite, principally on account of the greater percentage of hydrogen in the former fuel.

The combined effect of the flue gas temperature and the weight of flue gas determined the flue gas loss for various rates of heat input to the furnace. In this connection it may be observed, that it would be possible to still further reduce the flue gas temperatures by the addition of effective heating surface to the furnace. This would result in a smaller flue gas loss for all combustion rates, and hence in an increased efficiency. As indicated by the top set of curves in Fig. 15a the flue gas loss for a given value of heat input was approximately the same for oil (oil-burning furnace) and for anthracite. In other words, the combustion efficiencies in the two cases were approximately the same. Hence, some explanation involving factors in addition to combustion efficiency must be sought to account for the differences obtained in the heat input for a given difference in temperature between indoors and outdoors.

In the case of anthracite, the automatic control varied the rate of combustion so that it approximately corresponded with the heating demands of the house; namely with the difference in temperature between indoors and outdoors. Hence the combustion efficiency, as determined by the rate of combustion and therefore the heat input to the furnace, would be directly reflected in the curves of heat input to the house, Fig. 14, which are based on the temperature difference between indoors and outdoors.

However, in the case of oil, the rate of oil input, or the hourly heat release, was constant for all weather conditions, and control was obtained by adjustments in the length of time that the burner was allowed to operate. Therefore, the combustion efficiency would be dependent on this rate of heat release and not on the temperature difference between indoors and outdoors. Furthermore, the net flue gas loss for a 24-hour period, during which

the burner was operated intermittently, would be determined not only by the combustion efficiency but also by the total length of time during which the burner was actually in operation. The oil burner was so adjusted that the hourly heat release was somewhat greater than the hourly heat loss from the house on the maximum day. The hourly heat release in the case of anthracite, however, was just sufficient to offset the hourly heat loss from the house. Hence even on the maximum day the hourly heat release in the case of the oil-burning furnace was greater than that for anthracite, and the curves in Fig. 15a show that, although the combustion efficiencies for the oil-burning furnace and the anthracite were the same at the same heat release, during the actual periods of operation the flue gas loss was greater and therefore the combustion efficiency was less for the oil-burning furnace than it was for the anthracite. Since the rate of oil input remained the same for all weather conditions it is therefore evident that the oil-burning furnace always operated at a less combustion efficiency than the anthracite during the periods of actual operation. The net flue gas loss during a 24-hour period would be determined by the product of the hourly flue gas loss during the actual operating period and the total hours of burner operation during the day. The calculated values of net flue gas loss shown in Fig. 15b were derived from the data presented in Fig. 15a and are consistent with the experimental data for the heat inputs shown in Fig. 14 in that the curves representing higher flue gas losses in Fig. 15 correspond in position with those representing the higher heat inputs in Fig. 14. It is the total amount of the net flue gas loss over a given period of time rather than the combustion efficiency alone, that determines the relative position of the curves of heat input shown in Fig. 14.

This analysis of the factors affecting the net flue gas loss indicates that in order to secure minimum flue gas losses from an oil burner, the flue gas temperatures and the weight of the products of combustion should be maintained at a minimum value. This condition can be most nearly approached by adjusting the rate of oil input so that the heat release just offsets the heat loss from the house in the most severe weather. This analysis also suggests that if the rate of oil combustion could be varied to conform at all times with the heating demands of the house, an overall house efficiency equal to that obtained with anthracite should be possible of attainment. Since the combustion efficiency is affected by the amount and location of the heating surfaces, the necessity of providing adequate and effective heating surface is apparent.

A comparison of fuel costs, based on prices paid in Urbana, Illinois, for an average heating day is of interest. From Fig. 14 for an indoor-outdoor temperature difference of 33 F the values of heat input per day were 1,830,000 Btu, 1,600,000 Btu and 1,470,000 Btu for the conversion unit, the oil-burning furnace, and anthracite furnace, respectively. Based on unit fuel costs of 7.0 cents per gallon for oil having a calorific value of 144,200 Btu per gallon, the cost per therm is 4.85 cents. For anthracite costing $16.50 per ton, having a calorific value of 13,200 Btu per pound the cost per therm is 6.25 cents. The daily fuel costs based on these unit costs are given in Table 3.

It may be noted that the fuel costs for an average heating day were 77.6 cents, 88.8 cents, and 92.0 cents for the oil burning furnace, the oil conversion unit, and anthracite, respectively. These cost comparisons, of course, are valid only for the unit cost of fuels listed in the table and apply to prices paid in Urbana, Illinois.

Conclusions

The following conclusions may be drawn as applying to the Research Residence and the conditions under which the tests were conducted.

(1) The capacity and efficiency of oil-burning, warm-air furnaces are dependent upon seven factors:

1. Type of burner

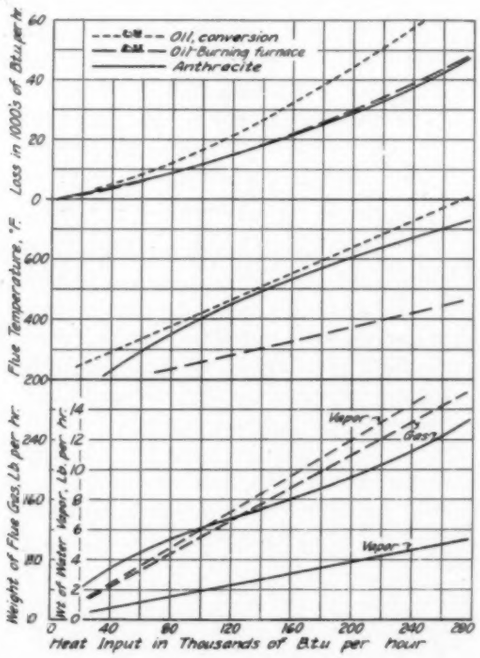

Oil, conversion
Oil-Burning furnace
Anthracite
Flue Temperature, °F. Loss in 1000's of Btu per hr
Weight of Flue Gas, Lb per hr
Wt of Water Vapor, Lb per hr
Vapor
Gas
Heat Input in Thousands of Btu per hour

Fig. 15a—Analysis of flue gas losses

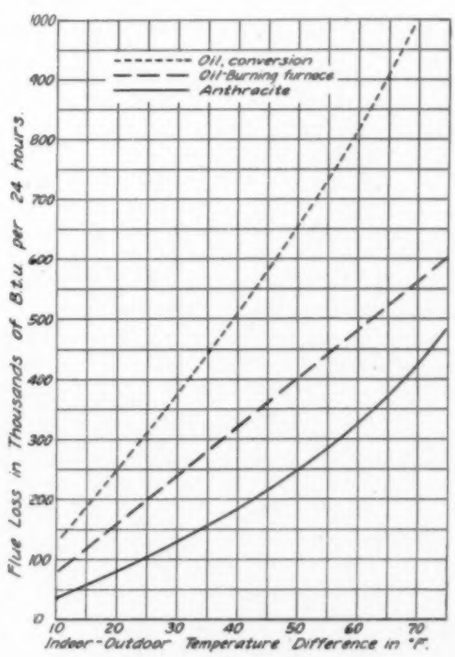


Fig. 15b—Calculated total flue loss

Table 3—Relative Fuel Costs for an Average Heating Day
(See Fig. 14)
(Based on prices in Urbana, Illinois)

	Anthracite	Oil-Burning Furnace	Oil Conversion Unit
Unit cost of fuel.....	$16.50 per ton	7 cents per gallon	
Calorific value	13,200 Btu per lb	144,200 Btu per gallon (19,500 Btu per lb)	
Cost per therm[a] in cents..	6.25	4.85	
Heat input for 33 F temp. diff. per 24 hours.....	1,470,000 Btu 14.7 therms	1,600,000 Btu 16.0 therms	1,830,000 Btu 18.3 therms
Fuel cost for average day, in dollars	0.92	0.776	0.888

[a]One therm is equivalent to 100,000 Btu.

2. Rate of oil input
3. Percentage of CO_2 in flue gas
4. Condition of draft in combustion chamber
5. Amount and location of heating surfaces
6. Size and shape of combustion space
7. Quantity of circulating air.

(2) With a constant percentage of CO_2 in the flue gas, and a constant rate of oil input, the efficiency and capacity of the furnaces using oil as a fuel were increased when the quantity of air circulated was increased.

(3) With a constant quantity of air circulated and a fixed rate of oil input to the furnaces using oil, the capacity and efficiency of the unit were not materially increased when the CO_2 content in the flue gas was increased from 9.5 per cent to 11.5 per cent.

If furnaces using oil as a fuel are provided with sufficient effective heating surface for a given rate of oil input, so that the temperature of the leaving flue gases will be low, then the unit may be expected to perform satisfactorily under diverse conditions of installation in the field, even with fairly wide deviations in the adjustment of the fuel-air ratio for the oil burner.

(4) Under normal service conditions, the operation of the burner for relatively short periods, during which a high rate of combustion was maintained, was not as good from the standpoint of fuel economy as the operation of the burner for longer periods, during which a lower rate of combustion was maintained.

(5) Seasonal operating costs of an oil-fired, forced-air heating system based only on the cost of fuel may be misleading, since the total cost of operation including the electrical costs should be considered.

(6) For an average heating day, or a day on which the indoor-outdoor temperature difference was 33 F, the requirements of the oil-burning furnace as compared with the requirements of the conversion unit showed a net reduction in fuel oil of 11.5-lb per day and a net reduction in electrical energy of 0.2 kwhr per day.

(7) For the same weather conditions, the heat inputs to the furnace were less and the overall efficiencies were greater for anthracite than for oil.

The temperature of the flue gases alone is not a reliable index of combustion efficiency when comparing different fuels. In fact, the total amount of the net flue gas loss during a 24-hour period, rather than the combustion efficiency alone, determines the magnitude of the heat input required to maintain house temperatures.

(8) Based on unit costs of 7 cents per gallon for fuel oil and $16.50 per ton for anthracite, the fuel costs for an average heating day, or a day in which the indoor-outdoor temperature difference was 33 F, were 77.6 cents, 88.8 cents, and 92.0 cents for the oil-burning furnace, the oil conversion unit, and the furnace burning anthracite, respectively.

Acknowledgments

The results presented in this paper were obtained in connection with the investigation of warm-air furnaces and heating systems in the Research Residence[6], Fig. 1, at the University of Illinois, conducted by the Engineering Experiment Station of which M. L. Enger, Dean of the College of Engineering, is the director, in the Department of Mechanical Engineering of which O. A. Leutwiler, Professor of Mechanical Engineering Design, is the head. This investigation is a cooperative project sponsored jointly by the *National Warm Air Heating and Air Conditioning Association* and the Engineering Experiment Station. These results will ultimately comprise part of a bulletin of the Engineering Experiment Station. Acknowledgment is also due to J. S. Cunningham, former Research Assistant, for services rendered in connection with the investigation, and to the various manufacturers who cooperated by furnishing instruments and equipment.

[6]The Research Residence in Urbana, Ill., was built, furnished, and completely equipped specifically for research work in warm-air heating by the *National Warm Air Heating and Air Conditioning Association* in December, 1924.

Where Exhaust Systems Are Practical

In a paper presented before the 25th Annual Safety Congress and Exposition held in Atlantic City, October 5-9, M. I. Dorfan* inferred that the primary consideration of an exhaust system should be the material to be exhausted. Generally the problem which confronts the engineer for systems handling dust, vapor, fume, or gas is not when and where is an exhaust system practical, but more frequently what *kind of an exhaust* can be made to overcome the tendency of moisture to condense into air, with its attendant precipitation of the dust which begins to accumulate and build up in the duct to a point where the duct clogs and the exhaust system no longer operates.

To make a practical exhaust system function under such conditions, the designer must find the means of either introducing extra air to absorb the moisture or evaporate such moisture as may be troublesome.

A further element of a good exhaust system and its practicability of operation is accomplished by careful consideration of the effects of the installation. Immediately after the equipment has been installed, dust determination counts made in the workroom should be effected as well as means for determining the movement of air with regard to human occupancy.

*Mgr., Dust Control Div., Blaw-Knox Co., Pittsburgh, Pa.

Handbook of Engineering Fundamentals

A new handbook prepared by a staff of specialists under the editorship of O. W. Eshbach has been released for the purpose of embodying in a single volume those fundamental laws and theories of science which are basic to engineering practice. This volume is essentially a summary of the principles of mathematics, physics and chemistry, the properties and use of engineering materials, the mechanics of solids and fluids, and the commonly used mathematical and physical tables. Thus, with the exception of techniques of surveying and drawing, there is included the fundamental technology common to nearly all engineering curricula.

Handbook of Engineering Fundamentals, by O. W. Eshbach, comprises 1,081 pages and is available from John Wiley & Sons, Inc., 440 Fourth Ave., New York City, at $5.00 per copy.

NOMINATIONS FOR 1937

The Nominating Committee appointed to select candidates for Officers of the Society for the coming year, 1937, submits the following list of nominees:

For President:

D. S. BOYDEN, Boston, Mass.

For First Vice-President:

E. H. GURNEY, Toronto, Ont., Can.

For Second Vice-President:

J. F. MCINTIRE, Detroit, Mich.

For Treasurer:

A. J. OFFNER, New York, N. Y.

For Members of the Council:

Three-Year Term

J. J. AEBERLY, Chicago, Ill.
M. C. BEMAN, Buffalo, N. Y.
E. O. EASTWOOD, Seattle, Wash.
W. A. RUSSELL, Kansas City, Mo.

Respectfully submitted,

NOMINATING COMMITEE,

J. H. VAN ALSBURG, *Acting Chairman;*
R. J. TENKONOHY, *Secretary.*

In accordance with the provisions of the Amended Constitution, as given, ballots containing the names of the above candidates will soon be sent to the membership for voting upon prior to the Annual Meeting in January.

Art. B-VIII—Section 10. The Nominating Committee shall consist of one (1) member eligible to vote designated by each Chapter, or his alternate also appointed by the Chapter. The Secretary of each Chapter shall certify to the Secretary of the Society on or before January first the names of the member and alternate selected.

The Committee shall meet at the Annual Meeting of the Society at the call of the Secretary of the Society and shall effect its own organization and elect its own Chairman. At the Semi-Annual Meeting of the Society, if possible, the Nominating Committee shall select the nominees for the ensuing year for the offices of President, First Vice-President, Second Vice-President, Treasurer, and four (4) members of the Council. In any event the names of the nominees shall be certified to the Secretary of the Society before September twentieth, with the written consent of each nominee to fill the office for which he has been selected and their names with the offices to which they have been nominated shall be published in the October issue of the JOURNAL.

Art. B-IX—Section 2. The Secretary shall prepare ballots with the names of all candidates and forward them to the members, eligible to vote, at least thirty (30) days before the date of the Annual Meeting.

Nominations for Members of Committee on Research

Although committees of the Society are usually appointed, in view of the great importance of the Committee on Research and the financial responsibility it would be called upon to assume, it has been made more representative of the entire membership of the Society by a process of *election*. The election is governed by the By-Laws for the election of officers, with the single exception that Members of the Committee on Research are nominated by the Council instead of by a Nominating Committee.

In accordance with the Regulations for the Government of the Research Laboratory, adopted at the January, 1919, Meeting, and amended January, 1933, the Council announces the nomination of the following members of the Committee for election to succeed those members whose present terms expire January, 1937:

Three-Year Term

H. E. ADAMS, South Norwalk, Conn.
A. E. STACEY, New York, N. Y.
G. L. TUVE, Cleveland, Ohio.
J. H. VAN ALSBURG, Chicago, Ill.
J. H. WALKER, Detroit, Mich.

The regulations governing the nomination and election of members of the Committee on Research are as follows:

ARTICLE II—ORGANIZATION

Section 1. *Committee on Research*—There shall be a standing committee known as the Committee on Research, consisting of fifteen (15) members each serving for three (3) years and five (5) retiring each year. The outgoing Chairman if serving in that capacity during the last year of his three (3) year term on the Committee shall without election become an additional member of the Committee on Research for one (1) year.

(*a*) The Council shall nominate previous to July first of each year five (5) members to fill the vacancies of those retiring at the next Annual Meeting.

(*b*) The nominations made by the Council shall be published in the October issue of the Society's JOURNAL.

(*c*) Any ten (10) members of the Society eligible to vote may present to the Secretary over their signatures, the name of one (1) or more additional nominees for the Committee on Research, provided such name or names are presented at least sixty (60) days prior to the next Annual Meeting, and such additional nominations shall be placed on the ballot opposite the nominations made by the Council.

(*d*) The election shall otherwise conform to the regulations provided for the election of officers of the Society in the Constitution, By-Laws and Rules.

(*e*) Vacancies may be filled by the Council, such persons chosen by the Council to serve until a successor is elected at the next Annual Meeting.

C. R. Davis
General Chairman

L. W. Moon
Vice-Chairman

Welcome to S

THE program for the Society's 43rd Annual Meeting to be held in St. Louis, January 25-27, has been completed and St. Louis Chapter members await the arrival of their fellow members at the headquarters established in the Hotel Statler.

A novel feature of the Meeting will be a conference of delegates from local Chapters on Monday morning, January 25, in advance of the technical sessions. The speakers will be Pres. G. L. Larson, First Vice-President D. S. Boyden, W. A. Russell, Chairman Membership Committee, and W. H. Driscoll, Past President of the Society.

The technical sessions will open at 2 p. m. Monday afternoon, January 25, with Pres. G. L. Larson presiding. Reports of the officers and important committees will be given. The papers cover a variety of subjects such as heat transmission, duct design, performance of outlets and grilles, fan characteristics, noise elimination, oil burner, stoker and vacuum pump performance.

An important contribution to the meeting will be several papers on physiological studies carried on in the laboratory and in hospitals. A discussion of these subjects in the four technical sessions should provide much interesting information for those who attend.

C. R. Davis, Chairman of the Arrangements Committee, announces a special dinner and Night Club Party from 7 p. m. to 12 midnight on Monday evening. It will provide a chance to get together for a renewal of old friendships and the making of new ones. Tickets for this party can be secured in advance from the Entertainment Committee, which has arranged to have dinner served on the Roof Garden of the Hotel Statler, at 7 p. m. with two floor shows—one at 8 p. m. and the second at 10, with dance music furnished by Al Roth's Orchestra.

The banquet on Tuesday night will be in the form of a dinner-dance at 7:30 p. m., January 26, in the ballroom of Hotel Statler. Vocal selections will be given during dinner and Al Roth and his Columbia Broadcasting Band will entertain and furnish music for dancing. E. B. Langenberg will act as toastmaster and an address will be made by Dr. A. C. Willard, President, University of Illinois.

The Ladies Committee working under the direction of J. W. Cooper has a delightful program for the visiting ladies. On Monday afternoon tea will be served in the St. Louis Chapter room in the Hotel Statler, and at 3 p. m. a talk on precious gems by an expert designer of jewels will be given. On Tuesday before noon, the ladies will assemble for an auto trip and luncheon party. Inspection will be made of the flowers in Shaw's Garden, and the New Jewel Box. Luncheon will be served at Garavelli's, and then a visit will be made to the Jefferson Memorial where the Lindbergh Trophies are on display.

After the final technical session, an interesting inspection trip has been planned and from 2 to 5 p. m. a visit will be made to the Anheuser Busch power plant and an inspection of the brewery.

A special announcement from the St. Louis Chapter, hotel reservation cards, and other literature describing the city of St. Louis, will be mailed to members early in December.

Several Chapters are contemplating organizing special parties to go to St. Louis in special cars. Railroads are offering low rates and inquiry should be made of local ticket agents regarding the lowest available cost of transportation. Air lines have special round-trip fares that may appeal to members in many cities.

The St. Louis Chapter and its Committee on Arrangements urge that members make their plans early for the Meeting, January 25-27.

P. W. Sodemann
Transportation

D. J. Fagin
Entertainment

E. E. Carlson
Publicity

J. W. Cooper
Ladies

C. E. Hartwein
Finance

G. W. F. Myers
Banquet

R. J. Tenkonohy
Reception

St. Louis

Technical Program

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Hotel Statler, St. Louis, Mo.
January 25-27, 1937

Sunday, January 24

10:00 a. m. Council Meeting

Monday, January 25

9:00 a. m. Registration

9:30 a. m. Committee Meetings

10:00 a. m. Conference of Chapter Delegates.
Speakers—President G. L. Larson
W. A. Russell, Chairman Membership Committee
W. H. Driscoll
D. S. Boyden

First Session, Monday, January 25

2:00 p. m. Greeting
Response by Pres. G. L. Larson
Reports of Officers and Council
Report of Committee on Research
Thermal Properties of Concrete Construction by F. B. Rowley, A. B. Algren and Robert Lander
The Specific Characteristics of Fans by M. C. Stuart and J. B. Lusk

Second Session, Tuesday, January 26

9:30 a. m. Technical papers—
A Rational Method of Duct Design by L. G. Miller
The Noise Characteristics of Air Supply Outlets by D. J. Stewart and G. F. Drake
Noise in Ventilating Systems and Methods for Its Elimination by J. S. Parkinson

Third Session, Tuesday, January 26

2:00 p. m. Technical papers—
Investigations on the Exchanges of Energy Between the Body and Its Environment by Dr. Charles Sheard and Dr. M. M. D. Williams
Fever Therapy Induced by Conditioned Air by F. C. Houghten, Dr. M. B. Ferderber and Carl Gutberlet
Cooling Requirements for Summer Comfort Air Conditioning by F. C. Houghten, F. E. Giesecke, Cyril Tasker and Carl Gutberlet
Report of Committee on Constitution and By-Laws
Report of Publication Committee
Report of Guide Publication Committee

Fourth Session, Wednesday, January 27

9:30 a. m. Technical papers—
Heat Losses and Efficiencies of Fuels in Residential Heating by R. A. Sherman and R. C. Cross
Performance of Oil-Fired, Warm-Air Furnaces in the Research Residence by A. P. Kratz and S. Konzo
Condensate and Air Removal Rates in a Vacuum Heating System by D. W. Nelson
Installation of Officers
Unfinished Business
New Business
Adjournment

12:30 p. m. Council Luncheon and Meeting

Jay R. McColl

Jay R. McColl

It is with extreme sorrow that the death of Jay R. McColl at his home, 825 Chicago Boulevard, Detroit, Mich., on October 30, 1936, is recorded. Mr. McColl's friends in the engineering profession are legion, and he had a long professional career closely identified with heating and ventilating. He joined the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS in 1916 and served with distinction as a member of the Council from 1920 to 1922, chairman of the Committee on Research in 1921, Second Vice-President in 1920, First Vice-President in 1921, and as President in 1922. At the time of his death, he was a member of the Society's Advisory Council. He also maintained an active interest in the affairs of the local Michigan Chapter, which he served as Vice-President in 1917. He was greatly interested in research and was intimately associated with the establishment of the A.S.H.V.E. Research Laboratory.

Jay R. McColl was born March 24, 1867, at Webster, Mich., and after graduating from the Ann Arbor High School he studied engineering at the Michigan State College where he received the degree of B.S. in 1890 and later he took post-graduate work at Cornell University.

From 1890 to 1892 Mr. McColl was an instructor in engineering at the University of Tennessee where from 1892 to 1902 he served as head of the Mechanical Engineering Department. He then went to Purdue University where for three years until 1905 he was head of the Steam Engineering Department. Mr. McColl became mechanical engineer for American Blower Co. in 1905 and was in charge of all heating and ventilating work. In 1910 he resigned to practice consulting engineering with the firm of Ammerman McColl and later with McColl, Snyder & McLean, engaged in heating, ventilating, lighting and power plant work for office buildings, hospitals, schools, theaters, banks, etc. In 1913 Mr. McColl was appointed dean of the newly created engineering college at the University of Detroit and he served in this capacity until the time of his death.

In 1922 Mr. McColl was made a member of the Michigan Board of Agriculture, serving until 1934. He also was a member of the Board of Rules of the City Department of Building and Safety Engineering. Mr. McColl was a member of the *American Society of Mechanical Engineers,* the *Detroit Engineering Society,* of which he was a past president, and the *Michigan Agricultural College Alumni Association,* having been president. His other memberships included Phi Delta Theta, Phi Kappa Phi, the Detroit Board of Commerce, Detroit Athletic Club, Detroit Yacht Club, Ingleside Club and the Meadowbrook Country Club.

He had served on the editorial staff of the *Michigan Architect and Engineer* and was the author of numerous papers for engineering societies and journals.

Surviving are his wife, Mrs. Belle Gertrude Baldwin McColl, formerly of St. Johns, whom he married Jan. 3, 1900; a daughter, Mrs. Jennette B. McColl Lawrence, a member of the *Free Press* staff; two sisters, Miss Jennie McColl and Mrs. W. R. Scadin, and two brothers, Irving G. and O. W. McColl.

Funeral services were conducted at his home Sunday by the Reverend Dr. Charles H. Meyers of the North Woodward Congregational Church, and interment took place at St. Johns, Mich., on Monday.

The officers and members of the Council of the A.S.H.V.E. keenly feel the loss which has been sustained in the death of Jay R. McColl and express their sincere sympathy and sorrow to his family who survive.

Percival H. Seward

In the death of Percival H. Seward at Boston, Mass., on November 16, the Society lost one of its Charter Members who always maintained a keen and active interest in A.S.H.V.E. affairs. He was the last survivor of the little group that was present at the founding of the Society. He always gave freely of his time and energy in support of the national organization and the New York Chapter, of which he was president in 1918. For many years he resided at 369 Washington Ave., Brooklyn, N. Y.

Mr. Seward was born at Chatteris, Cambridge, England, on December 27, 1871. Coming to the United States in 1887, he went directly to the West and joined his brother on a ranch in Dakota. After his brother returned to England, he started to make his own way and shortly obtained a position as a plumber's helper at Minneapolis, Minn. He then went to Syracuse, N. Y., with the American Boiler Co., and was sent to New York in 1896. Later he started in the contracting business in Brooklyn, New York, under the name of the Seward Engineering Co. He was associated with the Model Boiler Co. and continued with McCrum Howell. Afterwards he was connected with the Richmond Radiator Co., which he served as president, and later he was associated with C. W. Woolley of the American Radiator Co. in research work until his retirement from active business in 1930.

In 1931 Mr. Seward was granted Life Membership by the Council of the Society, and his death is sincerely regretted by A.S.H.V.E. officers and members of the Council as well as many members of the Society to whom he was known.

On the 25th anniversary of the organization of New York Chapter, November 16, just prior to Mr. Seward's death, a fine tribute to his loyalty and service to the Society as a member and as president of New York Chapter was given by W. H. Driscoll.

Mr. Seward is survived by his son, Halvor R. Seward of Newton Center, Mass., and funeral services were held Thursday afternoon, November 19, in the Newton, Mass., Cemetery Chapel.

Michigan Chapter Honors J. F. McIntire and Is Host to Pres. G. L. Larson

November 9, 1936. The regular meeting of Michigan Chapter was held at the Wardell Hotel at 6:30 p. m. with an approximate attendance of 100 members and guests and the principal function of this meeting was to honor J. F. McIntire, who has been nominated for Second Vice-President of the A.S.H.V.E.

After dinner, Pres. R. K. Milward called the meeting to order and asked for roll call and the secretary's report. A telegram was read from A. V. Hutchinson, secretary of the Society, expressing sorrow for the death of J. R. McColl. Secy. G. H. Tuttle read resolutions on the deaths of Edward Glanz and Mr. McColl, and it was unanimously voted that the resolutions be spread upon the minutes and that copies be send to the widows and families.

J. D. Cunningham was introduced by President Milward and discussed The Work and Functions of the Federal Bureau of Investigation. Mr. Cunningham outlined the growth of the Bureau and the science of fingerprinting and called attention to the necessity of both criminal and civil fingerprinting for identification purposes.

C. W. Farrar, Buffalo, N. Y., toastmaster of the evening, was then introduced, and in turn presented the following members, who spoke of Mr. McIntire's activities in connection with Michigan Chapter and the A.S.H.V.E.: G. D. Winans, J. H. Walker, E. M. Harrigan, R. L. Spitzley, L. L. McConachie, Prof. F. J. Linsenmeyer, E. N. McDonnell, Chicago, H. E. Paetz, H. A. Hamlin, and F. R. Bishop.

In response, Mr. McIntire thanked the members and officers.

President Milward then introduced W. G. Boales, who gave a short discussion on membership.

The meeting adjourned at 10:30 p. m.

October 15, 1936. The first meeting of the 1936-37 season was held at the Wardell Hotel. Approximately 65 members and guests were present.

Following dinner, Pres. R. K. Milward asked for roll call and the reports of the secretary and treasurer. W. G. Boales reported on new members, the status of limited chapter memberships, and the procedure for reinstatement of former members.

Prof. G. L. Larson, Madison, Wis., president of the A.S.H.V.E., who was the speaker of the evening, was introduced by President Milward and reported on the national membership status of the Society. President Larson predicted that THE 1937 GUIDE, of which J. H. Walker is chairman of the Guide Publication Committee, would be outstanding in the history of the Society, and in calling attention to the Annual Meeting of the A.S.H.V.E. in St. Louis in January, he spoke of the cooperation received from members of the medical profession in presenting two papers on Physiological Effects of Air Conditioning.

President Larson then gave his discussion of The Economics of Good Construction in Residence Heating and Air Conditioning. Taking a typical residence as an example, Professor Larson pointed out the economies of insulation on ceiling and side walls, weatherstripping and storm sash. He also discussed humidity and expressed the opinion that 50 per cent relative humidity with an inside temperature of 70F might be desirable as far as comfort is concerned, but is not practical with present construction.

The meeting adjourned at 10:00 p. m. with a rising vote of thanks to Professor Larson.

Pres. G. L. Larson Guest of Illinois Chapter; Water Problems Discussed

November, 9, 1936. The regular November meeting of the Illinois Chapter was held at the Hotel Sherman, in the Crystal Room, with an attendance of 116, and the meeting was called to order by Pres. J. J. Hayes.

After reading the minutes of the October meeting, President Hayes announced the following personnel of the Chapter committee appointed to study the water supply and water disposal problem in connection with Chicago air conditioning installations: O. W. Armspach, *Chairman*, John Howatt, G. W. Hubbard, L. L. Narowetz, Jr., and H. M. Hart.

J. R. Vernon, treasurer of the Chapter, took charge of the meeting and introduced the speaker of the evening, Prof. G. L. Larson, president of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and chairman of the Mechanical Engineering Department of the University of Wisconsin, whose subject was The Economics of Good Construction as Related to Residence Heating.

Professor Larson took an average 8-room house, without insulation, weather-stripping or storm windows, and, using values in THE GUIDE, figured the effect of insulation, weatherstripping and storm windows on the size of the heating plant and operating costs. He showed tables with the reduction in heat loss effected by the use of these insulating methods which ranged from a reduction of 3⅓ per cent by the use of ½ in. ceiling insulation to 56 per cent by the combined use of storm windows, storm doors and 4 in. of ceiling and wall insulation.

He then pointed out that these reductions in heat loss could effect a saving in the original cost of the heating plant and in the yearly operation which would more than pay for the additional cost of construction. He explained that these values would, of course, vary in different climates but, apparently, they could vary considerably and still show a substantial saving.

In the matter of humidification, Professor Larson found that no such economies were possible and that the gain was one of benefit to health, furniture, etc. He explained that with humidification heat is needed to vaporize the air and, though the temperature may be lowered when there is proper humidification, there is no economy in fuel. He stated that there are limitations to humidification which need further test work before arriving at definite conclusions.

Considerable discussion followed, ranging from the desirability of getting greater publicity on figures such as Professor Larson presented to the various practical problems that arise in heating work, which make it important that each job be carefully engineered before assuming that such values apply.

Secy. C. E. Price has reported that the meeting adjourned at 10:20 P. M.

October 12, 1936. Pres. J. J. Hayes called the meeting of Illinois Chapter to order at the Hotel Sherman, Chicago, when 175 members and guests were present.

Before proceeding with the regular order of business, President Hayes called upon John Howatt, who, in behalf of the Illinois Chapter, presented J. H. Milliken, president of the Chapter during the 1935-36 term and general chairman of the Arrangements Committee for the 42nd Annual Meeting of the Society, with a handsome desk set bearing a gold plate appropriately inscribed. Mr. Milliken responded with appreciation for the Chapter's action and expressed the hope that he could continue to serve its interests.

President Hayes announced the chairmen of the committees for 1936-37: Tom Brown, *Membership;* L. S. Ries, *Meetings and Publications;* J. R. Vernon, *Finance;* and J. H. O'Brien, *Legislative.*

Applications for membership from L. D. Stacy, J. H. Van Alsburg, and V. L. Sherman were read and accepted, as well as Secy. C. E. Price's report of the Society's Semi-Annual Meeting.

The speaker of the evening was L. D. Gayton, acting city engineer, City of Chicago, and his subject, Air Conditioning—Chicago's Water Problem. Mr. Gayton was introduced by Mr. Howatt and proceeded to give an informative paper on the present and probable future demand upon Chicago's water supply system; the ability of the water supply to meet the demands; the ability of the sewers to carry away the waste water; and possible solution of the problem.

In his discussion Mr. Gayton considered only the central business district of the city and stated that in this locality as of

September 1, 1936, there were 398 air conditioning installations with a total refrigerating capacity of 11,865 tons. On a basis of 2 gal of water per minute per ton of refrigeration required for condensing purposes, these present installations would use approximately 34,000,000 gal of water per day.

It was estimated that present air conditioning installations represent 16 per cent of the future potential in this area and that this potential would be reached within 20 years. In that event, 295,000,000 gal of water per day would be required for air conditioning alone.

Mr. Gayton stated that the present facilities for supplying water to this area are sufficient to meet all demands, including air conditioning, for the next 10 years and plans for the future will keep the supply abreast or ahead of all possible requirements. The sewers, however, represent an acute problem for air conditioning, as they were declared inadequate for normal demands of the city in 1910. Mr. Gayton told of the difficulties involved in the rebuilding of the entire sewer system in the Loop area and stressed, therefore, the solution of so designing and installing air conditioning equipment that the amount of water required would be reduced to a minimum, using cooling towers, evaporative condensers or other devices.

An interesting discussion followed and those taking part included P. J. Marschall, E. P. Heckel, J. J. Aeberly, M. G. Harbula, I. E. Brooke and G. W. Hubbard.

O. W. Armspach moved that President Hayes appoint a committee of five Chapter members to study this water supply and water disposal problem and the motion was seconded and carried. Mr. Gayton announced that his department was going to carry on a survey of the situation and offered its help to the Chapter Committee.

School Heating and Ventilating Operating Conditions Discussed by Massachusetts Chapter

October 13, 1936. Twenty-three members of Massachusetts Chapter and several guests enjoyed a dinner and meeting at Massachusetts Institute of Technology, when W. A. McPherson, heating engineer, Boston School Board, was the speaker of the evening.

The subject of Mr. McPherson's lecture was The Performance of Various Heating and Ventilating Systems under Actual Operating Conditions. The speaker presented a complete report of the conditions which were encountered in various school classrooms by a committee consisting of Prof. James Holt, Prof. C. P. Yaglou, Prof. J. H. Keenan and Mr. McPherson. The committee visited schools in the metropolitan district, which are equipped with various types of heating systems such as warm air furnace, indirect system with hot blast unit, plenum fan system, unit ventilator system with gravity vent, direct radiation only, window ventilation with vent fan exhaust, direct radiation, etc. All tests were made without advance notice so that actual operating conditions were studied.

The conditions in the classrooms were recorded by means of an electrical anemometer to determine air velocities and distribution. Wet- and dry-bulb readings were taken of the delivered air, including 7 dry-bulb readings at various points in the classroom, as well as the dry-bulb of the vent, and a sample of air was tested for carbon dioxide content. The object of these tests was to determine the relative effectiveness of distribution in relation to volume of air supplied per pupil and the resulting condition of the air. Where possible, tests were run on opposite sides of the same school to eliminate the variations due to outdoor prevailing conditions. The results of the tests were carefully tabulated and shown by lantern slides and many interesting conclusions were indicated.

Mr. McPherson also showed some slides which were unusual and interesting from a historic basis, depicting the earliest known applications of heating and ventilating systems to school houses in New England.

A further discussion of the subject was presented by Alfred Kellogg, which was followed by a general discussion and some remarks by Professor Yaglou, who was responsible for compiling the data in graph form and analyzing the results.

Secy. John Turner reports that the consensus of the meeting indicated that this was one of the most interesting discussions held, as it appealed to a large proportion of the members.

Philadelphia Chapter Enjoys Visit of Pres. G. L. Larson

November 12, 1936. Philadelphia Chapter held its regular meeting at the Engineers Club at 8:00 p. m. with Pres. W. F. Smith presiding, and 61 members and guests were present for dinner while 72 attended the meeting.

The Chapter was honored in having as its guest, Prof. G. L. Larson, Madison, Wis., president of the A.S.H.V.E., and several other visitors. After a delightful dinner, President Smith called the meeting to order and asked F. D. Mensing to give a history of the Philadelphia Chapter. Mr. Mensing recalled to memory the early days of the Society and the formation of the Philadelphia Chapter group.

President Smith introduced the guests, Professor Baker and Prof. H. P. Billings, Drexel Institute, Professor Morehouse, Villa Nova, Professor Thoms, Swarthmore, and Mr. Harbison, of the A.S.M.E.

Routine business was in order and the minutes of the previous meeting and the Treasurer's report were read and approved.

When President Smith called for nominations for the Nominating Committee, A. J. Nesbitt presented the following names: J. H. Hucker, *Chairman,* W. P. Culbert, R. C. Bolsinger, J. M. Jopson, and L. C. Davidson. On motion duly made and seconded the nominations were closed and Secy. H. H. Erickson was instructed to cast a ballot for their unanimous election.

L. P. Hynes spoke of the splendid activities of the Engineers Club, and C. B. Eastman, chairman of the Meetings Committee told of plans for the December meeting.

J. D. Cassell was called upon and presented the guest and speaker of the evening, President Larson, whose delightful narratives and instructive and interesting paper proved to be one of the best presented in recent years and was received with enthusiasm by the Chapter members and guests. The title of President Larson's talk was The Economics of Good Construction as Related to Residence Heating and it was illustrated by slides.

On behalf of the Philadelphia Chapter, M. F. Blankin thanked Professor Larson for his splendid paper and President Smith adjourned the meeting at 10:00 p. m.

Ontario Chapter Entertains President Larson and Discusses Weather

November 2, 1936. The regular meeting of Ontario Chapter was held at the Royal York Hotel and dinner was served at 6:30 p. m. with 50 members and guests present.

Vice-Pres. G. A. Playfair presided in the absence of Pres. Thomas McDonald.

Following dinner, Cyril Tasker was called upon to introduce the principal speaker of the evening, A. J. Connor, Dominion climatologist, who gave an illustrated talk on Weather as Related to Air Conditioning.

Following Mr. Connor's enjoyable address, H. B. Jenney extended a vote of thanks to the speaker on behalf of the Chapter.

October 13, 1936. This was the first meeting of the season and 47 members and guests were present at the Royal York Hotel to welcome Prof. G. L. Larson, Madison, Wis., president of the A.S.H.V.E., who was the guest of honor.

It was the unanimous opinion of the meeting to have Secy. H. R. Roth send a letter of condolence to the family of the late R. J. Millar.

It was moved by H. D. Henion, and seconded by G. A.

Playfair that J. W. O'Neill be the representative of Ontario Chapter on the A.S.H.V.E. Nominating Committee.

Pres. Thomas McDonald appointed a Weather Committee, consisting of J. W. O'Neill, *Chairman,* M. W. Shears, J. H. Fox and Cyril Tasker.

R. G. Heard was presented with the Board of Governors' golf trophy by E. R. Gauley.

President McDonald called upon A. V. Hutchinson, secretary of the Society, who spoke on the Activities of the A.S.H.V.E. Throughout the Dominion and the United States.

President Larson was then presented and gave a very enjoyable talk on The Economics of Good Construction in Residence Heating and Air Conditioning. Following the address, there was an interesting discussion and Mr. Tasker extended a vote of thanks to President Larson for his splendid discussion.

P. S. Hedley, *President*

C. A. Gifford, *Secretary*

Western New York

Secy. C. A. Gifford has prepared the annual report of the Western New York Chapter, and the following officers and committee chairmen are now serving:

President—P. S. Hedley.
1st Vice-President—B. C. Candee.
2nd Vice-President—J. J. Landers.
Secretary—C. A. Gifford.
Treasurer—L. P. Saunders.
Board of Governors—M. C. Beman, Joseph Davis, Roswell Farnham, D. J. Mahoney, W. E. Voisinet.
Program Committee—B. C. Candee, *Chairman.*
Entertainment Committee—Joseph Davis, *Chairman.*
Membership Committee—J. J. Landers, *Chairman.*
Attendance Committee—H. D. Hexamer, *Chairman.*
Publicity Committee—T. I. Messenger, *Chairman.*
Air Conditioning Standards Committee—M. C. Beman, *Chairman.*

Meetings were held from October, 1935, through June, 1936, and a brief outline is included.

October 14, 1935. Speaker—L. T. Avery, Avery Engineering Co., Cleveland, Ohio. Subject—Current Fallacies and Problems of Air Conditioning. Meeting—Touraine Hotel, Buffalo, N. Y. Attendance, 108 members and guests.

November 20, 1935. Speaker—L. A. Harding, Harding-Carlton Corp., Buffalo, N. Y. Subject—Standards for Summer Air Conditioning. Attendance, 73 members and guests. Touraine Hotel.

December 17, 1935. Christmas Party. Social evening. Attendance, 38 members and guests. University Club.

January 13, 1936. Speaker—D. Harper, Westinghouse Electric and Manufacturing Co. Subject—Motor Applications and New Developments. Attendance, 41. Touraine Hotel.

February 10, 1936. General Forum and Informal Discussion. Comfort Standards for Air Conditioning as submitted by committee. Attendance, 52. Touraine Hotel.

March 9, 1936. Speaker—E. P. Hanning, Reading Iron Co. Subject—Three Reels of Motion Pictures Describing the Manufacture of Wrought Iron Pipe from Mine to Finished Product. Attendance, 52. Touraine Hotel.

April 13, 1936. Speaker—W. E. Stark, Bryant Heater Co., Cleveland, O. Subject—Complete Air Conditioning With Gas; Silica Gel; Cooling With Gas. Attendance, 48. Touraine Hotel.

June, 1936. Golf meet and dinner. South Shore Country Club. Attendance, 19.

Oklahoma City Chapter Hears Talk on Differential System of Heating

November 11, 1936. The meeting was held in the electric bungalow of the Oklahoma Gas and Electric Co. and was called to order at 8:00 p. m. by Pres. F. X. Loeffler. Twenty members and guests were in attendance.

The minutes of the October meeting were read and approved and mention was made again of the importance of applying for membership in the Society before the first of the year.

President Loeffler introduced C. A. Thinn, chief engineer, C. A. Dunham Co., Chicago, who spoke on the Differential System of Heating.

Announcement was made that the December meeting would be devoted to the presentation of a paper on Cooling Requirements for Summer Air Conditioning prepared by the Society's Research Laboratory and a discussion of the proposed air conditioning standards for Oklahoma.

Secy. E. W. Gray reports that the meeting adjourned at 10:30 p. m.

Manitoba Chapter Holds Business Meeting and Discusses Housing Act and Rehabilitation

October 22, 1936. The eighth meeting of Manitoba Chapter was held at the Fort Garry Hotel and, following roll call, Secy. C. H. Turland read a summary of summer activities.

The Nominating Committee recommended that Pres. J. B. Steele and William Glass be chosen to represent Manitoba Chapter as representative and alternate respectively on the A.S.H.V.E. Nominating Committee. It was moved by H. R. Eade, seconded by E. F. Munn and unanimously carried that the report be adopted.

R. L. Kent was elected to present the paper on the subject of Cooling Requirements for Summer Air Conditioning prepared by the A.S.H.V.E. Research Laboratory at the November 26 meeting.

E. F. Munn, D. F. Michie and William Glass were appointed as a committee to work on Chapter V of THE A.S.H.V.E. GUIDE in conjunction with Prof. F. B. Rowley.

An Entertainment Committee for the December meeting was appointed composed of C. H. Turland and J. E. Yates, Jr.

The guest speaker of the evening was L. L. Anthes, Toronto, vice-president, National Construction Council, and honorary secretary, *Canadian Construction Association,* who chose as his subject, The Dominion Housing Act and Rehabilitation Scheme. This proved to be a timely and interesting subject to those engaged in engineering and building.

Mr. Eade moved that a vote of thanks be given to Mr. Anthes and the meeting adjourned at 10:30 p. m.

Kansas City Chapter Discusses Automatic Heating Boilers

October 1, 1936. The first Fall meeting of the Kansas City Chapter was held at the Newbern Hotel at 6:15 p. m. with 26 members present for dinner. A vote was taken on the desirability of continuing the meetings at the Newbern Hotel for the coming year and the decision was found to be unanimously in favor.

Pres. L. R. Chase presided and announced the appointment of a Program Committee consisting of Prof. A. H. Sluss, *Chairman,* L. A. Stephenson, E. K. Campbell, Jr., and J. N. Sawyer.

W. A. Russell, chairman of the Society's Membership Committee, gave a brief discussion on the subject of new members taken into the various chapters of the A.S.H.V.E., and the 13 new members of Kansas City Chapter represented an excellent showing.

The guest speaker of the evening was R. F. Connell, Detroit,

who was introduced by Mr. Russell. Mr. Connell's able presentation of the subject of Design and Operation of Automatic Heating Boilers held the complete attention of all present. He pointed out that probably one of the most important factors in design was the matter of price limitation. Mr. Connell stressed the importance of burner setting and application as a factor in proper burner operation. He indicated the importance of detailed consideration of transmission rates for proper comparison of different makes of boilers and spoke of the fact that some manufacturers include piping and pick-up reserves in their ratings, while others do not, causing additional confusion.

A discussion was held after the presentation which clearly indicated the members' interest in the subject, according to the report of Secy. F. J. Dean, Jr.

Pres. G. L. Larson Visits Cleveland Chapter and Discusses Residence Construction

November 11, 1936. One hundred and five members and guests attended the regular meeting of the Cleveland Chapter at the Cleveland Club, which was preceded by dinner and a business meeting attended by 54 members and guests.

The October minutes were read and accepted, and the Treasurer's report was read and approved by the Auditing Committee. A motion was made and carried approving actions taken by the officers during the preceding year.

R. A. Wilson, chairman of the Membership Committee, reported two new local members—Mr. Maple and Mr. Wilhelm —both of whom were unanimously accepted into the chapter.

L. C. Minnie reported for the Publication Committee, and F. A. Kitchen for the Legislation Committee.

Prof. G. L. Tuve offered a resolution asking that the Society's Council collect chapter dues when the national dues are collected, refunding accordingly to the local chapters. This resolution was passed and the Secretary was instructed to submit it to the Council.

Pres. L. T. Avery then turned the meeting over to F. A. Rodgers, chairman of the Program Committee, who introduced the guest speaker, Prof. G. L. Larson, Madison, Wis., president of the A.S.H.V.E.

Professor Larson first told of the membership growth of the Society, the increased sale of THE GUIDE and the research work being carried on at the Laboratory in Pittsburgh. He stated that the Annual Meeting will be held in St. Louis the last week in January and mentioned interesting papers which are scheduled for presentation.

President Larson then gave a very interesting illustrated talk on the Economics of Good Construction in Residence Heating and Air Conditioning with particular attention to insulation, storm windows and weatherstripping.

An interesting discussion followed in which many in the audience took part.

Mr. Rodgers announced that the December meeting would be held on December 14 when the subject of Comfort Cooling Requirements would be discussed.

According to the report of Secy. W. R. Beach, the meeting was adjourned at 11:00 p. m.

October 20, 1936. A dinner and business meeting of the Cleveland Chapter was attended by 24 members and was followed by an open meeting at which 75 members and guests were present at the Cleveland Club.

The minutes of the June meeting were accepted, and the Secretary's annual report for Cleveland Chapter was read to the meeting.

Pres. L. T. Avery encouraged members to take an active part in chapter activities and accept committee assignments.

F. R. Dickinson, chairman of the Program Committee, spoke of tentative arrangements for future meetings, and R. A. Wilson, chairman of the Membership Committee, announced the filing of A.S.H.V.E. membership applications by J. P. Jones and H. K. Jennings.

F. A. Kitchen, chairman of the Legislation Committee, spoke on the State of Ohio Code Regulation, Rule No. 19, pertaining to ventilation requirements in public buildings such as theaters, auditoriums and school buildings.

A revised chapter constitution was presented in the prescribed manner by the Constitution Revision Committee of which Mr. Kitchen is chairman and M. F. Rather and C. F. Eveleth are members. The constitution was accepted by the chapter with several changes, and will become effective as soon as approved by the Society's Council.

Prof. G. L. Tuve was authorized to prepare a resolution for submission to the A.S.H.V.E. Council relative to Chapter Dues.

F. R. Dickinson, vice-president of the Chapter, tendered his written resignation occasioned by his leaving the city of Cleveland, and this was accepted. The Nominating Committee, which had previously been advised of this action, offered the name of Philip Cohen as vice-president, and Mr. Cohen was elected unanimously. The Nominating Committee then presented the name of W. R. Beach to succeed Mr. Cohen as secretary, and Mr. Beach was elected unanimously.

Nomination and election of chapter representatives to the A.S.H.V.E. Nominating Committee was the next order of business and resulted in the unanimous election of Prof. G. L. Tuve as representative and W. R. Beach as alternate.

The meeting was then given over to H. E. Wetzell, chairman of the Standards Committee, who led a discussion on Air Conditioning Standards for the Cleveland area. E. B. Carey of the Standards Committee reviewed the present standards of the Western New York Chapter in Buffalo, N. Y. Prof. C. A. McKeeman, also of the Standards Committee, reviewed the present standards of the *Air Conditioning Manufacturers' Association.*

After an interesting general discussion it was moved that a topical outline of standards for discussion and ultimate acceptance by the chapter be prepared by the Standards Committee.

H. P. Waechter Joins W. T. Grant Co.

Herman P. Waechter has become associated with the W. T. Grant Co., and will be in charge of designing, purchasing and maintaining air conditioning systems to be installed by this department store chain. Mr. Waechter was formerly designing engineer and erection supervisor with York Ice Machinery Corp.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate to membership by letter ballot. During the past month 41 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn the Coun-

cil, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by December 15, 1936, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
BARTON, JAY, Gen'l. Mgr., Mfg. Div., Nelson Co., Detroit, Mich.	E. B. Root F. R. Bishop	W. F. Arnoldy B. F. McLouth
BEARMAN, A. A., Engr., In charge of Air Cond. plant, 20th Century-Fox Film Corp., New York, N. Y.	H. W. Fiedler C. R. Hiers	G. E. Olsen H. G. Meinke
BEECHLER, J. S., Air Cond. Engr., Kelvinator Corp., Detroit, Mich.	Roy Conrad H. F. Hutzel	C. A. Rickner R. F. Connell
BIANCULLI, V. A., Draftsman, S. A. S. Patorno, New York, N. Y.	S. A. S. Patorno C. R. Hiers	W. M. Heebner L. M. Parter (*S.A.E.*)
BROWN, WILLIAM, Vice Pres., The Carey Co., Detroit, Mich.	R. K. Milward W. G. Boales	G. D. Winans G. H. Tuttle
CHEATWOOD, W. H., Installation Engr., Interstate Elec. Co., Shreveport, La.	H. F. Hutzel Roy Conrad	R. F. Connell W. G. Boales
COX, T. M., Jr., Sales Engr., Neal & Massy Engrg. Co., Ltd., Port of Spain, Trinidad, B. W. I.	V. S. Day Donald French	N. E. Sheldon J. N. Hirst (*Non-Member*)
DEPPMANN, R. L., Mgr., R. L. Deppmann Co., Detroit, Mich.	W. G. Boales F. R. Bishop	W. C. Randall F. J. Feely
DIXON, M. F., Combustion Engr., Imperial Oil, Ltd., Montreal, Que., Can.	G. L. Wiggs C. W. Johnson	A. F. Lamontagne W. U. Hughes
DOLSON, C. N., Sales Engr., R. F. Knoche & Son, Hamburg, N. Y.	S. R. Rente W. E. Voisinet	M. C. Beman P. S. Hedley
FEINBERG, EMANUEL, Sales Engr., Ilg Elec. Vtg. Co., Detroit, Mich.	A. H. Kirkpatrick G. H. Tuttle	R. K. Milward W. G. Boales
FORD, E. F., Sales Repr., American Radiator Co., Detroit, Mich.	M. B. Shea W. G. Boales	W. C. Randall F. J. Feely
FREDERICK, W. L., Pres., Bryant Air Cond. Corp., Washington, D. C.	R. H. Feltwell W. E. Kingswell	E. V. Fineran Leon Ourusoff
GITTERMAN, HENRY, Dist. Repr., Independent Air Filter Co., New York, N. Y.	H. W. Fiedler W. E. Heibel	H. G. Meinke A. J. Offner
GURNEY, E. R., Asst. Engr., Gurney Fdry. Co., Toronto, Ont., Can.	D. I. Paul W. R. Blackhall	H. H. Angus G. B. Beatty (*Non-Member*)
HAMAKER, A. C., Mgr. Home Htg. Dept., The J. L. Hudson Co., Detroit, Mich.	F. R. Bishop W. G. Boales	W. C. Randall F. J. Feely
HESS, A. J., Design Engr., E. L. Ellingwood, Los Angeles, Calif.	O. W. Ott W. E. Barnum, Jr.	H. M. Hendrickson Tom Dickinson
HYDE, E. H., Tech. Repr., Koppers Co., Pittsburgh, Pa.	W. A. Danielson E. O. Rhodes (*A.C.S.*)	E. H. Streeter (*A.C.S.*) E. W. Clarke (*Non-Member*)
IVERSON, H. R., Br. Engr., The Trane Co., Washington, D. C. (*Advancement*)	T. H. Urdahl L. F. Nordine	R. H. Feltwell M. D. Kiczales
JELINEK, F. R., Sales Engr., Johnson Service Co., Detroit, Mich.	J. S. O'Gorman, Jr. J. R. Vernon	G. H. Blanding J. A. Cutler
JENNINGS, H. K., Sales Engr., Avery Engrg. Co., Cleveland, Ohio.	L. T. Avery R. A. Wilson	F. A. Rodgers K. W. Schick
KEYSER, H. M., Sales Engr., Murray W. Sales & Co., Detroit, Mich.	F. R. Bishop C. W. Farrar	F. J. Feely W. C. Randall
KING, H. K., Dist. Mgr., Tube-Turns, Inc., Louisville, Ky.	F. J. Feely W. G. Boales	G. D. Winans R. K. Milward
KONZO, SEICHI, Special Research Assoc., University of Illinois, Urbana, Ill. (*Advancement*)	A. P. Kratz W. H. Severns	M. K. Fahnestock E. L. Broderick
LONG, D. J., Sales Engr., W. G. Boales Co., Detroit, Mich.	W. G. Boales G. H. Tuttle	G. D. Winans W. P. Arnoldy
LOUGHRAN, P. H. JR., Cadet Engr., Washington Gas Light Co., Washington, D. C.	Leon Ourusoff W. H. Loving	E. V. Fineran W. E. Kingswell
MCCREA, J. B., Htg. & Vtg., Detroit, Mich.	R. K. Milward W. G. Boales	G. D. Winans G. H. Tuttle
MURDOCH, J. P., JR., Pres., John P. Murdoch Co., Philadelphia, Pa.	W. P. Culbert J. M. Jopson	G. E. Tuckerman H. H. Erickson
NOBLE, J. P., Dist. Engr., Air Cond. Dept., Frigidaire Corp., Dayton, Ohio.	C. E. Lewis J. J. La Salvia	M. J. Stevenson H. B. Hull
PAINTER, D. H. Mfr. Repr., Hoffman Specialty Co., Kansas City, Mo. (*Reinstatement and Advancement*)	F. H. Gaylord C. W. Adams	W. A. Russell F. J. Flynn
PAQUET, J. M., Design Engr., J. A. Y. Bouchard, Ltd., Quebec, Que., Can.	F. R. Barnsley G. L. Wiggs	W. U. Hughes F. G. Phipps
PERRAS, G. E., Htg. Expert, Thos. Robertson & Co., Ltd., Montreal, Que., Can.	G. L. Wiggs C. W. Johnson	A. F. Lamontagne W. U. Hughes
SCHMIDT, KARL, Jr., Htg. & Vtg. Engr., Detroit City Gas Co., Detroit, Mich.	J. P. Schechter W. G. Boales	G. D. Winans F. J. Feely

SHAW, C. G., Engrg. Design, Brazelton Lumber Co., Waco, Tex.	F. E. Giesecke E. P. Renouf	W. H. Badgett C. L. Kribs
SNAVELY, A. B., Chief Engr., Hershey Chocolate Corp., Hershey, Pa.	I. H. Geiger P. L. Pryibil	J. H. Hucker W. A. Danielson
STEHL, H. V., Sales Engr., Campbell Metal Window Corp., Baltimore, Md.	J. E. Seiter J. deB. Shepard	R. N. Downs T. A. Garner (*Non-Member*)
TAYLOR, H. J., Htg. Contractor, Detroit, Mich.	W. G. Boales H. E. Paetz	G. H. Tuttle R. K. Milward
WAGNER, E. A., Pres., Wagner Engrg. Corp., Pittsfield, Mass. (*Advancement*)	Elliott Harrington P. S. Lyon	D. W. McLenegan F. S. Hunting (*Non-Member*)
WARE, J. H., 3rd, Vice Pres., City Gas & Fuel Co., Oxford, Pa.	J. M. Traugott P. L. Pryibil	A. G. Dome J. H. Hucker
WOOD, R. A., Editorial Asst. Fueloil Journal, New York, N. Y.	Eugene Fezandie (*A.S.M.E.*) J. I. Yellott (*A.S.M.E.*)	L. D. Becker (*Non-Member*) Fred Ostertag (*Non-Member*)
ZWALLY, A. L., Air Cond. Engr., Interstate Elec. Co., Shreveport, La.	H. F. Hutzel Roy Conrad	R. F. Connell W. G. Boales

Candidates Elected

In past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

ARMBRUSTER, F. T. W., Sales Engr., The Portsmouth Supply Co., Portsmouth, Ohio.

BENNETT, E. A., Sales Engr., American Blower Corp., New York, N. Y. (*Advancement*)

BLAS, R. J., Air Cond. Engr., Sanchez & Ca., Caracas, Venezuela.

BOZEMAN, R. W., Engr., Lexington, Ky., (*Reinstatement and Advancement*)

CLARK, E. H., Mfrs. Agent, Detroit, Mich. (*Reinstatement*)

CODY, H. C., Sales Engr., Pierce, Butler Radiator Corp., Philadelphia, Pa. (*Reinstatement*)

DES REIS, J. F., Field Mgr., Carrier-Brunswick Internat'l., Newark, N. J.

GONZALEZ, R. A., Mgr., Application Engrg., Airtemp, Inc., Dayton, Ohio.

HELMRICH, G. B., Mech. Engr., The Detroit Edison Co., Detroit, Mich.

JONES, D. J., Control Engr., Vapor Car Htg. Co., Inc., Chicago, Ill. (*Reinstatement*)

KNAPP, J. H., Designing Engr., Utica Products Corp., Utica, N. Y.

MCKEEMAN, C. A., Asst. Prof. Mech. Engrg., Case School of Applied Science, Cleveland, Ohio.

MUELLER, H. C., Asst. Sales Mgr., Powers Regulator Co., Chicago, Ill. (*Advancement*)

MUELLER, H. P., Pres., L. J. Mueller Furnace Co., Milwaukee, Wis.

RUGGLES, R. F., Dist. Mgr., Autovent Fan & Blower Co., New York, N. Y. (*Reinstatement and Advancement*)

SKAGERBERG, RUTCHER, Market Development Engr., Brown Instrument Co., Penn Wynne, Pa. (*Reinstatement*)

THOMAS, GLEGGE, Gov. Repr., Clarage Fan Co., Washington, D. C. (*Reinstatement*)

VELTMAN, B. M., Htg. Design & Sales, Brown Sheet Iron & Steel Co., St. Paul, Minn.

WERNER, R. K., Consulting Mech. Engr., R. K. Werner, Cons. Engr., Ft. Worth, Texas.

WILSON, ALEXANDER, Consulting Engr., Montreal, Que., Can.

ASSOCIATES

ADAMS, B. P., Asst. Gen'l. Mgr., McDonnell & Miller, Chicago, Ill.

CAIRNS, J. H., Asst. Sales Engr., Frigidaire Corp., Toronto, Ont., Can.

CAMERON, W. R., Dist. Mgr., L. J. Mueller Furnace Co., Milwaukee, Wis.

DICKINSON, TOM, Draftsman, York Ice Mach. Corp., Los Angeles, Calif.

DUPUIS, J. R., Dist. Mgr., Trane Co. of Can., Ltd., Montreal, Que., Can.

DURKEE, M. E., Sales Engr., C. A. Dunham Co., New York, N. Y. (*Reinstatement*)

FORRESTER, N. J., Chief Estimator, The Garth Co., Montreal, Que., Can.

HARBORDT, O. E., Sales Mgr., U. S. Supply Co., Kansas City, Mo.

JEX, JOHN, JR., Sales Engr., Mercoid Corp., New York, N. Y.

MADELY, F. J., Asst. Contract Engr., Eastern Steel Products, Ltd., Montreal, Que., Can.

MARSHALL, A. G., Sales Engr., Trane Co. of Can., Ltd., Montreal, Que., Can.

MCDONALD, A. K., Sales Engr., Standard Oil Co. of N. J., Washington, D. C.

MCDONNELL, J. E., Sales Engr., McDonnell & Miller, Chicago, Ill.

NELSON, E. L., Engrg. Dept., The Union Ice Co., Los Angeles, Calif.

NICKLE, A. J., Sales Engr., Darling Brothers, Ltd., Montreal, Que., Can.

SCHUETZ, C. C., Research Engr., U. S. Gypsum Co., Chicago, Ill.

SMITH, STUART, Br. Mgr., American Radiator Co., Cincinnati, Ohio.

SWANSON, N. W., Sales Engr., McDonnell & Miller, Chicago, Ill.

WILKINSON, ARTHUR, Mgr., Wilkinson Engrg. Agencies, Montreal, Que., Can.

JUNIORS

FARBER, L. M., Design Engr., Natkin & Co., Kansas City, Mo.

KURTZ, R. W., Air Cond., Steam & Hot Water Inspector, City of Minneapolis, Minneapolis, Minn.

LA ROI, G. H., JR., Corresponding Engr., McDonnell & Miller, Chicago, Ill.

PRAWL, F. E., Sales Engr., Airtemp Div., Sidles Co., Lincoln, Nebr.

PRINCE, R. F., Engr., American Radiator Co., Boston, Mass.

SCHERRER, K. C., Design Engr., Natkin & Co., Kansas City, Mo.

STILES, G. S., Sales Engr., Airtemp Div., Sidles Co., Des Moines, Iowa.

STRAVITSCH, J. J., Estimator & Sales, Standard Air Conditioning, Inc., New York, N. Y.

WILEY, D. C., Engr., John J. Nesbitt, Inc., Chicago, Ill.

STUDENTS

CHENOWETH, D. M., Student, Purdue Univ., West Lafayette, Ind.

MOORE, D. R, Student, Purdue Univ., West Lafayette, Ind.

OGARD, N. L., Student, University of Minnesota, Minneapolis, Minn.

Heating • Piping and Air Conditioning

January-December, 1936—Vol. 8, Nos. 1-12

As will be noted, these abstracts are classified under general heads. In looking for information on a specific subject, it will be well to look through the abstracts under the most suitable heading, and also to look through those under the other headings. For example, some of the heating articles also contain information on air conditioning, and vice versa, *as the grouping has been made on the basis of the subject most prominently covered in the article.*

The index to the Journal Section *of the* American Society of Heating and Ventilating Engineers *is separate* (*see page* 720).

This index does not include Equipment Developments; Book Reviews; Booklets, Reports, and Papers; Recent Trade Literature; and Conventions and Expositions, departments appearing regularly each month. The Editor's Page in each issue includes items of news, comments on current events, etc.

Directory Section.
Vol. 8, No. 1. January, 1936. *p.* 187 (*back section*).
Directory section of heating, piping and air conditioning equipment for industry and large buildings; products classified; trade names; manufacturers' names and street addresses.

Air Conditioning

Absorption Refrigeration Unit Cools Brine for Air Conditioning an Inn, by B. H. Jennings.
Vol. 8, No. 11. November, 1936. *p.* 590.
Absorption refrigeration unit for air conditioning Tressler Inn, Trevorton, Pa.; estimating power requirements; furnishing refrigeration for food storage; brine storage system; anthracite fired boiler unit; layout of equipment; control; air conditioners.

A. C. M. A. Conditioning Application Standards.
Vol. 8, No. 7. July, 1936. *p.* 98 (*back section*).
Application engineering standards for comfort air conditioning adopted by *Air Conditioning Manufacturers Association;* standards reprinted. (Also see August, 1936, issue, p. 91, back section.)

Adopt Standard Refrigeration Symbols.
Vol. 8, No. 9, September, 1936. *p.* 503.
Standard refrigeration symbols adopted by *Refrigeration Machinery Association* and *Air Conditioning Manufacturers Association.*

Air Condition the Bakery Throughout, by W. W. Reece.
Vol. 8, No. 8. August, 1936. *p.* 419.
Generally accepted applications of air conditioning in bakery plants; complete bakery air conditioning; layout of typical plant; air conditions required; segregating sources of heat; advantages of bakery air conditioning; plan of bakery showing conditions to be maintained in each department.

Air Conditioned Test Rooms Improve Product.
Vol. 8, No. 11. November, 1936, *p.* 617.
Advantages of air conditioning test rooms at Westinghouse plant.

Air Conditioning a Production Tool Since 1926 at Bayuk Cigars Plant, by Rush D. Touton.
Vol. 8, No. 1. January 1936. *p.* 14.
How and to what extent Bayuk employs air conditioning; changes required by increased production and new developments; operation and maintenance of spray banks and nozzles; use of off-peak refrigeration; design factor for industrial air conditioning; relocation of equipment; life and construction of air conditioning equipment; advantages of building insulation and double sash; treatment of spray water to prevent sludge formation; cost and advantages of air conditioning; diagram of rearrangement of equipment on ceiling which released usable floor space.

Air Conditioning Benefits Surgical Supply Company.
Vol. 8, No. 11. November, 1936. *p.* 594.
Brief description of air conditioning for manufacture of sutures; the process; advantages of air conditioning.

Air Conditioning for Health—Air Conditioning Gaining Acceptance by Medical Profession, by C. P. Yaglou.
Vol. 8, No. 9. September, 1936. *p.* 502.
Early work of Dr. John Gorrie; original model of Dr. Gorrie's ice machine; use of air conditioning in premature nurseries, operating rooms, post-operative ward; artificial fever; treatment of various diseases by air conditioning.

Air Conditioning for Health—Air Conditioning, in Replacing Ventilation, Introduces a Newer Viewpoint, by C.-E. A. Winslow.
Vol. 8, No. 10. October, 1936. *p.* 543.
Replacement of conception of ventilating by air conditioning a significant advance; importance of effect of air temperature upon human health, comfort and efficiency; odors; radiant and convected heat.

Air Conditioning for Health—Cooperation with the Medical Profession, by Walter L. Fleisher.
Vol. 8, No. 8. August, 1936. *p.* 426.
What can be learned about air conditioning through cooperation with the medical profession; medical profession divided into two groups; work of Dr. Mills and Dr. Huntington on effect of climate on civilization; Dr. Mills' chart on effect of weather on business activities; a great opportunity for cooperative research.

Air Conditioning Improves Quality of Honey; Apiaries Get 100% Return on Investment.
Vol. 8, No. 5. May, 1936. *p.* 268.
Hodgson Apiaries, Jarvis, Ontario, Canada; reasons for air conditioning; conditions maintained; advantages.

Air Conditioning Installations.
Vol. 8, No. 2. February, 1936. *p.* 99.
Number of air conditioning installations and connected horsepower for air conditioning for 11 months of 1935, 1934, and totals to date for five cities, supplementing data given in January, 1936, issue.

Air Conditioning Installations in Houston.
Vol. 8, No. 4. April, 1936. *p.* 207.
Number of air conditioning installations and connected horsepower for air conditioning for Houston, Texas, for 1934, 1935, and totals at end of 1935, supplementing data on other cities in January, 1936, issue.

Air Conditioning Makes Severe Demands on Water Supply and Disposal Systems.
Vol. 8, No. 9. September, 1936. *p.* 491.
General review; Lincoln, Nebr., ordinance; water main capacities limited in Cincinnati; summary of papers and articles on the subject; abstract of paper on air conditioning in relation to water consumption by L. L. Lewis; demand for water; water conservation with evaporative condensers; discussion of use of raw water for condensing purposes by Walter L. Fleisher; New York City regulations.

Air Conditioning Review.
Vol. 8, No. 1. January, 1936. *p.* 1.
Number of installations and connected horsepower for air conditioning for 1934, first 11 months of 1935, and totals as of Dec. 1, 1935, in approximately 40 cities; break-down by type of job—industrial, commercial and public, residential—for 10 cities; percentage increases; prospects for 1936.

Air Conditioning Ruler Aids Use of Psych Chart, by William Goodman.
Vol. 8, No. 8. August, 1936. *p.* 430.
Description of ruler for solving air conditioning problems; method of use in following problems—total heat removed in cooling air, volume of air to circulate, weight of moisture condensed; reproduction of ruler.

Air Outlet Fixture Adapts Existing Ventilating Ducts to Conditioned Air Distribution.
Vol. 8, No. 9. September, 1936. *p.* 474.
Novel air outlet fixture for two story auditorium; details; photograph.

Air Conditioning Windowless Office Building, by A. Bowman Snavely.
Vol. 8, No. 12. December, 1936. *p.* 675.
Hershey Chocolate Corp.'s windowless office building; brief description of air conditioning system; object of windowless design.

And Now—The Air Conditioned Billboard!
Vol. 8, No. 7. July, 1936. *p.* 364.
Wilson & Co. billboard, Chicago, has plate glass kennels in which are exhibited pedigreed dogs; air conditioning necessary; conditions maintained; equipment; insulation.

Apartment House in London Completely Air Conditioned, by J. W. Harvey.
Vol. 8, No. 9. September, 1936. *p.* 495.
Eaton House, London, England, air conditioned; choosing the type of system; separate system for each apartment; description of equipment; automatic control; silent operation essential; illustrations of equipment.

Ballroom Air Conditioning System Design and Control Complicated by Varying Day and Night Heat Loads, by F. W. Rabe.
Vol. 8, No. 6. June, 1936. *p.* 315.
Design of air conditioning system at Adolphus Hotel, Dallas, Texas; ammonia compressors; day and night ballroom cooling loads; evaporator design; use of psychrometric chart in computations; method of control; duct work; air conditioning flow diagram; rebuilt air compressor chills water.

Boulder Dam Engineers Solve Cooling, Ventilating Problems, by Carleton W. Campbell.
Vol. 8, No. 7. July, 1936. *p.* 386.
Controlling temperature of penstocks; ventilation of power house; heating offices and control rooms; cross-section of dam and photograph of model.

Box Strapping Holds Duct Insulation.
Vol. 8, No. 4. April, 1936. *p.* 210.
Ordinary steel box strapping used to hold board form duct insulation in place; method of installing; sketch.

Building Meters Air Conditioning Service, by Paul E. Holcombe.
Vol. 8, No. 8. August, 1936. *p.* 437.
Liquid refrigerant metered to allocate air conditioning costs between theater and balance of building load; three meters used; largest air cooled installation known.

Bureau of Standards Studies Determine Press Room Conditioning Requirements, by C. G. Weber.
Vol. 8, No. 3. March, 1936. *p.* 137.
Reaction of paper to humidity variations; determining proper press room air conditions; types of air conditioning systems for print shops; conditioning paper before printing; use of paper hygroscope; equilibrium moisture content of various papers; influence of moisture content variations on dimensions of lithographic papers; influence of hygrometric condition on moisture content change during multicolor printing.

Carlton Hotel Air Conditions, by T. D. Carson.
Vol. 8, No. 8. August, 1936. *p.* 439.
Carlton Hotel, Washington, D. C., one of first hotels to air condition bedrooms; earlier installation serves several rooms of eighth floor; the new installation: four fans supply bedrooms; control permits operating flexibility; evaporative condensers used.

Code for Ventilation and Air Conditioning.
Vol. 8, No. 6. June, 1936. *p.* 100 (*back section*).
Part XIII of heating code for Minneapolis, Minn., covering ventilation and air conditioning. (Also see p. 96, back section, July, 1936, issue.)

Comfort Cooled Bus Serves as Display Room.
Vol. 8, No. 10. October, 1936. *p.* 549.
Merchandise display bus comfort cooled; compressor; insulation.

Controls (Reference Sheet 1), by C. L. Ringquist.
Vol. 8, No. 9. September, 1936. *p.* 504.
Three diagrams showing methods of control of humidifying systems and cycles of operation.

Controls (Reference Sheet 2), by C. L. Ringquist.
Vol. 8, No. 10. October, 1936. *p.* 567.
Diagrams and description of five control systems for ventilating systems; explanation of operating cycles.

Controls, by C. L. Ringquist (Reference Sheet 3).
Vol. 8, No. 11. November, 1936. *p.* 618.
Diagrams and description of three control systems for ventilating systems; explanation of operating cycles.

Controls (Reference Sheet 4), by C. L. Ringquist.
Vol. 8, No. 12. December, 1936. *p.* 660.
Diagrams and description of three control methods for heating and ventilating systems, with explanation of cycles of operation.

Deep Well Water Does Double Job; Cools Offices, Then Goes to Process, by W. H. Wetherell.
Vol. 8, No. 12. December, 1936. *p.* 676.
Air conditioning system for office building of Dewey & Almy Chemical Co., Cambridge, Mass.; deep well water used in process bypassed through cooling and dehumidifying coils; zone control system for summer and winter; operation of controls.

Designing Vanes in Duct Elbows, by Samuel R. Lewis.
Vol. 8, No. 4. April, 1936. *p.* 208.
Designing intermediate vanes in square duct elbows of reducing type; chart for design of intermediate vanes; typical problem solved; sketch of solution.

Developing a Code for Comfort Air Conditioning, by L. A. Harding.
Vol. 8, No. 10. October, 1936. *p.* 555.
Brief review of background of code for comfort air conditioning for Buffalo, N. Y.; design temperature conditions; inlet temperatures; performance guarantees.

Drying with Lithium Chloride.
Vol. 8, No. 6. June, 1936. *p.* 325.
Brief description of method of drying industrial products by use of lithium chloride solution.

Early Comfort Cooling Plants, by G. Richard Ohmes and Arthur K. Ohmes.
Vol. 8, No. 6. June, 1936. *p.* 310.
Early methods of comfort cooling; method of cooling Vienna theater, 1900; newspaper article published in 1902; early hotel dining room job; Carnegie Music Hall installation, 1889; cooling a private home with mechanical refrigeration about 1893; dissecting room, 1899; New York Stock Exchange; paper on cooling and ventilation of hospitals, 1914; Cologne theater; Carnegie Safe Deposit Co., 1908; Metropolitan Museum of Art, 1907.

Effect of Air Conditioning Demand on City Water Supply and Sewer Systems, by Loran D. Gayton.
Vol. 8, No. 11. November, 1936. *p.* 609.
Effect of water required for air conditioning on Chicago's water supply and sewer systems; present water requirements; downtown area 16 per cent air conditioned; predicting future water demand; available supply; downtown sewer system overloaded by water wasted from air conditioning plants; possible solutions of the problem.

Engineering and Equipment for Air Conditioning Charted, by H. D. Betz.
Vol. 8, No. 5. May, 1936. *p.* 102 (*back section*).
Engineering and equipment required for air conditioning charted to show prospective purchasers what is involved; charts reproduced.

Even Rats Are Air Conditioned! by Paul W. Watson.
Vol. 8, No. 10. October, 1936. *p.* 557.
Air conditioned animal house at Abbott Laboratories, Chicago; calculating the cooling load; the installation and its control.

Fair Weather, by Charles L. Kribs, Jr.
Vol. 8, No. 8. August, 1936. *p.* 432.
Brief review of air conditioning installations at Centennial Exposition, Dallas, Tex.; conditioned exhibit spaces; fine arts museum conditioned throughout; steam unit heaters heat greenhouse; gas engine driven air conditioning compressors; air conditioning natural history museum.

For Comfort, Laboratory Insulates and Ventilates, by G. K. Saurwein.
Vol. 8, No. 6. June, 1936. *p.* 327.
Animal room for biology laboratory in attic; method of insulation and ventilation to maintain comfort, reduce animal death rate.

Get Ready Now for Winter Operation of Conditioning System, by Rush D. Touton.
Vol. 8, No. 10. October, 1936. *p.* 550.
Advantage of dividing operation procedures for air conditioning plants into seasonal intervals; surveying major equipment for winter operation; piping; humidification; air distribution; controls and instruments; insulation; building structure; electrical equipment; lubrication; fall overhauling and testing; check sheet for fall and winter air conditioning survey.

Glass Bricks Replace Windows, Reduce Condensation in Air Conditioned Plant, by L. Duckmann.
Vol. 8, No. 12. December, 1936. *p.* 656.
Windows at Oscar Heineman Corp. plant, Chicago, replaced with glass bricks; wooden sashed windows formerly used; method of installing the glass bricks; sketches.

Graphical Method of Determining Finned Coil Capacities Described, by E. P. Wells.
Vol. 8, No. 12. December, 1936. *p.* 665.
Factors affecting performance of finned dehumidifying coils; predicting performance of coil from a few tests; graphical method of presenting coil data; mechanism of heat transfer; finding the surface temperature; limitations of the method.

High Speed Sychronizing Motor Control for Air Conditioning Compressors Insures Minimum Lighting Disturbance, by R. C. Allen.
Vol. 8, No. 7. July, 1936. *p.* 370.
Necessity of synchronizing motors driving compressors for air conditioning; staggering compressor cranks; high speed synchronizing control at Kansas City Auditorium; diagram; operation; other applications; curve showing range of perceptible light flicker caused by voltage variations.

Hotels Find Air Conditioned Bedrooms Pay.
Vol. 8, No. 8. August, 1936. *p.* 441.
Brief reports of experience of thirteen hotels with air conditioned bedrooms; costs; methods; advantages; guests' remarks.

How to Avoid Trouble from Noise in Air Conditioning Installations, by P. H. Geiger.
Vol. 8, No. 11. November, 1936. *p.* 601.
Method of specifying loudness; comparison of loudness level and loudness scales; noise of air through grilles; comparison of loudness of grilles; correcting loudness curves for different size grilles; influence of surroundings on noise; sound absorption coefficients. (Also see December issue, p. 120, back section.)

How Much Noise Is Permissible? by P. H. Geiger
Vol. 8, No. 12. December, 1936. *p.* 657.
Permissible grille velocities; increase in loudness level of a room due to the addition of grille or other noise; instructions for use of curve; methods of reducing air conditioning equipment noise; flexible mountings; lining ducts.

How Sheet Metal Ducts Are Fabricated, by William Neubecker.
Vol. 8, No. 10. October, 1936. *p.* 542.
Seven types of construction for longitudinal duct seams; details; applications of each; supporting ducts.

Improving Office Air Conditions.
Vol. 8, No. 5. May, 1936. *p.* 124 (*back section*).
Answer to reader's question by Samuel R. Lewis; air cleaning and humidification required for office occupied by 50 persons; recommendations for installing equipment and its control.

Instruments Needed to Operate Air Conditioning Plants Properly, by William A. Hanley.
Vol. 8, No. 3. March, 1936. *p.* 139.
Temperatures and pressures to record for efficient operation of industrial air conditioning system; required recording instruments; maintenance of air conditioning systems; where failures occur; log sheet for recording operating data.

Keeping the Heat Out of Treated Space Leads to Economy in Air Conditioning, by Lester T. Avery.
Vol, 8, No. 1. January, 1936. *p.* 22.
Importance of surveying building to determine such changes as are economically sound before installing summer air conditioning system; restaurants are greatest offenders in having undesired heat sources; plan and elevation of typical restaurant used as example; table of heat gains before and after corrective treatment; methods of reducing heat gains—venetian blinds and awnings, wall insulation, ceiling treatment, hoods, lighting load; corrective treatment cuts heat load in half in this case.

Miniature Lake on Roof, Double Glass Walls, Cut Store Air Conditioning Load.
Vol. 8, No. 12. December, 1936. *p.* 659.
Air conditioned J. C. Penney Co. department store, Milwaukee, Wis.; roof cooled by waste condensing water; 20 tons refrigeration capacity saved; double glass walls used; power and water consumption.

Modernizing with Air Conditioning, by Anker Winther.
Vol. 8, No. 1. January, 1936. *p.* 7.
Why 15 story American Building, Cincinnati, Ohio, was air conditioned; considerations involved in choosing type of system; central station dehumidifier system decided upon; location of equipment; air circulation; new type of duct construction avoids expense of furring yet makes neat installation; duct layout for typical floor; control almost 100 per cent automatic.

National Silicosis Conference Outlines Objectives, by R. Campbell Starr.
Vol. 8, No. 8. August, 1936. *p.* 438.
Brief report of National Silicosis Conference; Secretary of Labor's remarks; silicosis as an employer problem; interest of labor; medical aspects of control; work of committees.

New Uses for the Psychrometric Chart in Simplifying Air Conditioning Problems, by William Goodman.
Vol. 8, No. 2. February, 1936. *p.* 87.
(Part 1); usefulness of psychrometric chart can be extended to solve many summer air conditioning problems for which it is not now utilized; absorption of sensible heat gains; absorption of moisture by air supply; absorption of total heat gain; the author's psychrometric chart; instructions for its use; table of heat ratio angles for various sensible heat ratios; examples.

New Uses for the Psychrometric Chart in Simplifying Air Conditioning Problems, by William Goodman.
Vol. 8, No. 3. March, 1936. *p.* 147.
(Part 2); required wet bulb of air supply; room conditions with given state of air supply; quantity of air circulated; typical problems solved graphically.

New Uses for the Psychrometric Chart in Simplifying Air Conditioning Problems, by William Goodman.
Vol. 8, No. 4. April, 1936. *p.* 197.
(Part 3); additional examples of solution of air conditioning problems; discussion of cases where sensible heat ratio is so low as to require reheating; table of quantity of air supply required for various rises in dry bulb temperature.

New Uses for the Psychrometric Chart in Simplifying Air Conditioning Problems, by William Goodman.
Vol. 8, No. 5. May, 1936. *p.* 262.
(Part 4); reheating chilled air supply to rooms having low heat ratios; run-around cycle; amount of sensible heat for reheating; temperature of air leaving cooling coils; sensible heat required for reheating for various dry bulb temperatures of air leaving cooling coils; typical problems worked out.

"Not Too Cool for Comfort," Hotel Metropole Advertises.
Vol. 8, No. 10. October, 1936. *p.* 541.
Balancing inside and outside temperatures in summer air conditioning; reproduction of advertisement of Hotel Metropole, Cincinnati, entitled "Not Too Cool on a Hot Day"; advantages of air conditioning hotel dining room.

Number of Air Conditioning Installations in Indianapolis and Vicinity.
Vol. 8, No. 6. June, 1936. *p.* 309.
Number of air conditioning installations, types of buildings conditioned, and horsepower for air conditioning as of April 15, 1936.

Operating Flexibility Features Air Conditioning and Heating of New St. Louis Auditorium.
Vol. 8, No. 5. May, 1936. *p.* 241.
Description of the building; air conditioned at 14 fan rooms; steam jet refrigeration; control of chilled water flow to dehumidifiers; sketch of chilled water risers; diagram of control of chilled water; operating instructions; the steam jet machines; cooling towers; pumping equipment; piping tunnel; detail of pipe guide; duct work and air distribution scheme; temperature and humidity control; recording and indicating instruments; motors and motor control; photographs of equipment; cross-section of building.

Pioneer User Says Air Conditioning Pays.
Vol. 8, No. 1. January, 1936. *p.* 18.
Remarks of M. A. Snyder, manager, Milam Building, San Antonio, Tex., on advantages of air conditioning office buildings; comments of tenants; air conditioning enabled renting basement space for cafe, cut cleaning and painting costs.

Purdue Experiment Station Reports on Effect of "Freon" on Fruit in Storage, by Clarence E. Baker.
Vol. 8, No. 3. March, 1936. *p.* 94 (*back section*).
Tests of "Freon's" toxicity to fruit described; apparently harmless to apples.

Savings Pay Operating Cost of Air Conditioning System, by A. J. Rummel.
Vol. 8, No. 4. April, 1936. *p.* 209.
Records of 12 months' operation of air conditioning system for insurance offices of United Services Automobile Association, San Antonio, Texas; description of system; sketches show details of system; control; cost of system, advantages of air conditioning, and saving achieved by utilizing air conditioning.

Standards for Air Conditioning Noise Control.
Vol. 8, No. 12. December, 1936. *p.* 652.
Section on noise control of revised edition of Chicago standards for comfort air conditioning; method of determining noise level of room.

Temperatures and Humidities for Tobacco Fermentation.
Vol. 8, No. 3. March, 1936. *p.* 114 (*back section*).
Answer to reader's question by Rush D. Touton; requirements vary; general recommendations.

The War on Noise, by Vern O. Knudsen.
Vol. 8, No. 9. September, 1936. *p.* 497.
Review of article on German developments in acoustics; German and American standards of noise measurement compared; measurement of impulsive sounds; filters for tubes and ducts; transmission of sound through walls and small openings; solid borne sounds; machine noises; curve showing relation between loudness and loudness level.

Place Air Intake to Avoid Pulling in Dust, by J. M. Pettingell.
Vol. 8, No. 9. September, 1936. *p.* 494.
Proper location of outside air intake; recommendations; what to avoid.

Portable Units Condition Air Liners.
Vol. 8, No. 7. July, 1936. *p.* 385.
Two types of portable cooling units used for precooling planes on the ground.

Power Requirements for Air Conditioning.
Vol. 8, No. 6. June, 1936. *p.* 328.
Power required depends upon application; floor area, volume, tons per 1000 sq ft, tons per 1000 cu ft for department store, office building, restaurant and theater; kilowatt hours per season per compressor horsepower. (Also see p. 377, July, 1936, issue.)

Pressure Losses in Rectangular Elbows, by R. D. Madison and J. R. Parker.
Vol. 8, No. 7. July, 1936. *p.* 365.
(Part 1); earlier tests; definition of terms—radius ratio, curve ratio; aspect ratio; apparatus and methods used in tests; effect of radius ratio; pressure loss in 90 deg elbows followed by ducts.

Pressure Losses in Rectangular Elbows, by R. D. Madison and J. R. Parker.
Vol. 8, No. 8. August, 1936. *p.* 427.
(Part 2); effect of aspect ratio; effect of degrees turn of elbow; effect of elbow size; effect of velocity.

Pressure Losses in Rectangular Elbows, by R. D. Madison and J. R. Parker.
Vol. 8, No. 9. September, 1936. *p.* 483.
(Part 3); effect of splitters on pressure loss; chart for determining location of elbow splitters; effect of elbows at the ends of ducts; effect of compound elbows on pressure loss; test results; pressure losses in elbows discharging directly into air; summary of Parts 1, 2 and 3.

Solving the Four Types of Process Air Conditioning Problems, by William Goodman.
Vol. 8, No. 6. June, 1936. *p.* 323.
(Part 1); all air conditioning problems fall into one of four classes depending upon whether sensible and latent heat are being added to or subtracted from the conditioned space; heating and humidifying; cooling and humidifying; quadrant on psychrometric chart into which each class of problem falls; tables of heat ratio angles; typical examples.

Solving the Four Types of Process Air Conditioning Problems, by William Goodman.
Vol. 8, No. 7. July, 1936. *p.* 373.
(Part 2); cooling and humidifying; heating and dehumidifying; cooling and dehumidifying; supplying latent heat deficiency; selecting condition of air supply; typical examples.

Supplement to the Chicago Air Conditioning Standards of October, 1935.
Vol. 8, No. 1. January, 1936. *p.* 156 (*back section*).
Supplement to Chicago standards for comfort air conditioning published in full; definitions; explanatory information on each section of the standards.

Temperature and Humidity Requirements for Air Conditioning the Meat Plant.
Vol. 8, No. 6. June, 1936. *p.* 312.
Table of temperatures and relative humidities most suitable for various departments of the meat plant.

Trouble Chart—Repulsion Induction Motors, by F. W. Butler.
Vol. 8, No. 6. June, 1936. *p.* 326
Symptoms and some of the most common causes of trouble with single phase repulsion induction motors; tests; remedies.

Tunnel Air Cools Hotel Guest Rooms.
Vol. 8, No. 9. September, 1936. *p.* 503.
Brief description of method of cooling guest rooms for Harding Hotel, Chicago, by means of cool air from freight tunnel system.

Use of Sewage Water as Condensing Medium for Air Conditioning Plants Has Possibilities, by E. P. Heckel.
Vol. 8, No. 12. December, 1936. *p.* 653.
Idea of using sewage water as condensing medium investigated; temperature; per cent of solids; acidity; scheme rejected for psychological reasons.

1200 Tons Refrigeration Required for Air Conditioning Kansas City Auditorium, by William L. Cassell.
Vol. 8, No. 9. September, 1936. *p.* 479.
Description of building; "Freon" refrigeration equipment; control of temperatures; air circulation; air distribution in auditorium; smoke exhaust; exhausting heat from lights; air washers and control; air conditioning exhibition space; theaters and other rooms; piping services and heating system; section through main auditorium; control board.

Two Well-Known Buildings to Be Air Conditioned.
Vol. 8, No. 4. April, 1936. *p.* 204.
Federal Reserve Bank and Wrigley buildings, Chicago, to be air conditioned; types of systems; photographs of the buildings.

"What Air Conditioning Did for My Business."
Vol. 8, No. 3. March, 1936. *p.* 140.
Comments of owners of air conditioning systems on business advantages of commercial air conditioning; candy shops; women's apparel store; drug store; warehouse of candy distributor; coffee shop.

What Is Air Conditioning?
Vol. 8, No. 10. October, 1936. *p.* 547.
Definition of air conditioning by A. C. Willard, President of the University of Illinois, at conference on air conditioning.

What the Operating Force Must Know for Effective, Efficient Air Conditioning, by Rush D. Touton.
Vol. 8, No. 9. September, 1936. *p.* 500.
Importance of instructing and training operating force; need of instruments; mistakes sometimes made; training should cover all fundamentals; information which should be furnished operating crew.

Why Cleaning's a Function of Air Conditioning.
Vol. 8, No. 11. November, 1936. *p.* 600.
Extract from address by J. J. Donovan; amount and kind of dirt in air in New York City.

Heating

After the Flood—Restoring Equipment to Service, by Samuel R. Lewis.
Vol. 8, No. 4. April, 1936. *p.* 196.
Brief review of how to restore heating, piping and air conditioning equipment to service after submergence in flood waters; boilers, electrical equipment, pumps, tanks, insulation, brick work; anchoring fuel oil tanks.

Boiler Combustion Space and Burner Control, by Kalman Steiner.
Vol. 8, No. 8. August, 1936. *p.* 444.
(A question and answer); firebox design for oil fired boilers; furnace volume, pitting the boiler; intermittent and high-low control; application of each.

Combustion Control for Oil Fired Boiler Plants, by Kalman Steiner and Paul R. Unger.
Vol. 8, No. 10. October, 1936. *p.* 544.
Primary object of combustion control system; five major factors; combustion controllers; draft controllers; synchronizing air to oil flow; regulation of oil pressure and compensation for oil viscosity; compensation for changes in pressure drop through boiler; diagram of metering type combustion control system.

Controlling Construction Costs, by C. C. Wilcox.
Vol. 8, No. 7. July, 1936. *p.* 378.
Committment method and weekly analyses enable control of expenditures for constructing central heating plant at St. Mary's Academy, South Bend, Ind.; method used; analysis of cost and man-hours of labor; brief description of plant.

Control Matches Boiler Operation to Hotel's Heat and Steam Requirements.
Vol. 8, No. 3. March, 1936. *p.* 135.
Gas fired boiler plant at 250-room Hotel Orlando, Decatur, Ill.; steam formerly purchased; importance of operating flexibility in a hotel; steam services; typical day's operation; the plant and its control; chart showing percentage of stack losses; gas consumption for month of January, 1936, and degree days.

Control of Indirect Water Heaters.
Vol. 8, No. 1. January, 1936. *p.* 178 (*back section*).
Answer to reader's question by Samuel R. Lewis; where install aquastat?

Efficiencies With Various Fuels.
Vol. 8, No. 6. June, 1936. *p.* 116 (*back section*).
Answer to reader's question by Paul R. Unger; boiler efficiencies with various fuels; factors affecting efficiency.

Forced Circulation Hot Water System Heats Plant in Change-Over, by Samuel R. Lewis.
Vol. 8, No. 1. January, 1936. *p.* 31.
Plant troubled with corrosion of heating system steam and return piping; high pressure steam employed; description of system; system changed to forced circulation hot water; change-over presented interesting problems; copper piping with sweat fittings used; control of and balancing the system; heat exchanger for heating circulating water with steam; open hatchway blanketed with warm air; diagrams of old and new systems; piping details.

Gas in Summer, Oil and Coal in Winter, Carry Palmer House Hotel Heating Load.
Vol. 8, No. 1. January, 1936. *p.* 12.
Boiler at Palmer House, Chicago, fired with gas in summer, oil in winter; description of the installation; method of control; gas consumption and efficiency; brief description of heating, piping and air conditioning services at this hotel; photos of gas and oil fired boiler; close-up of gas header; turbine driven gas boosters.

Handling Fuel Oil, by Kalman Steiner.
Vol. 8, No. 2. February, 1936. *p.* 91.
(Part 3); calculation for pressure drop in piping; selection of

pumping equipment; cost of pumping oil; horsepower requirements; sample problems computed.

Handling Fuel Oil, by Kalman Steiner.
Vol. 8, No. 3. March, 1936. p. 145.
(Part 4); methods of regulating oil pressure; types of oil strainers; strainer requirements and maintenance.

Handling Fuel Oil, by Kalman Steiner.
Vol. 8, No. 4. April, 1936. p. 201.
(Part 5); types of valves used; orifice plates; other flow regulators; advantages and disadvantages of each.

Heating and Ventilation of a Modern High School Building, by Robert P. Schoenijahn.
Vol. 8, No. 9. September, 1936. p. 469.
Pierre S. duPont high school, Wilmington, Del.; the boiler plant; stokers; soot blower system; turbine driven condensate vacuum pump; layout of steam mains; welded supply and return piping; insulation; traps; hot water service; unit ventilators and control; heating and ventilating gymnasium; program clock control cuts electrical demand; exhaust systems; summary of equipment.

Heating 10,000 Hens, by Kalman Steiner.
Vol. 8. No. 12. December, 1936. p. 657.
"White elephant" real estate investment converted into "poultry farm"; 10,000 egg laying hens occupy six-story industrial building; ventilating and heating requirements; oil fired boilers; air exhaust system; control of the fans and the burners; fuel consumption double the estimate; new thermostat settings and fan timer solve the problem; use of operations recorder in checking operation of system; a field for air conditioning?

How to Operate Oil-Fired Heating Plants Efficiently, by Paul R. Unger and Kalman Steiner.
Vol. 8, No. 5. May, 1936. p. 255.
Cleanliness the cardinal virtue; maintenance of equipment—flues, strainers, burner nozzles and tips, fans and blower wheels, oil heaters, storage tank; diagram showing method of valving oil preheater to permit cleaning; checking performance of safety devices—float operated devices, mercury tubes, relays, combustion safety switches, stack switches; fire hazard of storage tanks.

Moisture Retained by Coal.
Vol. 8, No. 1. January, 1936. p. 180 (back section).
Answer to reader's question by P. Nicholls; maximum percentage of water held by a ton of coal.

Outdoor Temperature Graph Aids in Heating Building for Morning Occupancy, by Joseph W. Degen.
Vol. 8, No. 2. February, 1936. p. 100.
Time—temperature graph used at Equitable Building, New York City, for better operation of heating system; enables operating engineers to see trend of temperature; diagram of the graph showing construction; results of its use.

Practical Heating—Boiler Ratings, by Harold J. Taylor.
Vol. 8, No. 3. March, 1936. p. 153.
Piping and pick-up load; oil burning boilers; steel boiler ratings; water heating load; multipliers for heat emission of radiation for air temperatures other than 70 F; Btu per hr heat emission for conditions other than standard; multipliers for temperature range other than 0-70 F; Btu per sq ft per hr with various water temperatures in radiator.

Practical Heating—Installing Vacuum Equalizing Line, by Harold J. Taylor.
Vol. 8, No. 7. July, 1936. p. 383
Installing vacuum equalizing line with two pipe vapor-vacuum heating systems to safeguard steam boiler from low water; method of installing; advantages.

Practical Heating—Notes on Unit Heaters, by Harold J. Taylor.
Vol. 8, No. 4. April, 1936. p. 203
Notes on correcting troubles caused by improper installation and maintenance; dirt; valves; traps; electrical; multi-speed motors; control; boiler load; hot water jobs; summer operation; diagrams showing piping.

Practical Heating—Notes on Vacuum and Condensation Pumps, by Harold J. Taylor.
Vol. 8, No. 7. July, 1936. p. 382.
Use of condensation and vacuum pumps; installation; suggestions for correcting troubles.

Practical Heating—Sizing Steam Coils for Heating Water, by Harold J. Taylor.
Vol. 8, No. 8. August, 1936. p. 434.
Figuring apartment building job; recommendations where water is hard; selecting the boiler; lineal feet of pipe per sq ft of surface; "heating power" of brass and iron pipe.

Practical Heating—Trouble-Shooting on Indirect Heater Jobs, by Harold J. Taylor.
Vol. 8, No. 6. June, 1936. p. 313.
What to check if heater fails to heat; suggestions for correcting the possible difficulties.

Pure Oil Building Cuts Cost of Heating, by Clyde Maxwell.
Vol. 8, No. 8. August, 1936. p. 421.
Opportunities to achieve economies in heating costs exist in many buildings; economies made at Pure Oil Building, Chicago; test run before and after reconditioning; rehabilitation of boilers; radiators and traps; pumping water; water treatment.

Reliable Steam Consumption Records Mean Better Heating at Minimum Cost, by Lyman R. Flook.
Vol. 8, No. 6. June, 1936. p. 320.
Importance of reliable records to economical operation of heating system; steam conservation efforts at University of Chicago; flow meters; meter testing; use of flow meter readings, monthly reports, analysis of steam consumption by groups of buildings, master record and budget forecast, and other forms.

Revamping the Building Heating System in the Modernization of Conners Creek, by Sabin Crocker.
Vol. 8, No. 1. January, 1936. p. 25.
Modernization of Conners Creek power house of Detroit Edison Co.; heat emission of power equipment upsets radiation computations; summary of building heating requirements; use of unit heaters; heating requirements of switching station; ventilation of turbine room; steam for building heating bled from turbo-generators; sections through generators showing control; relation of throttle steam flow, electrical output, and bled steam available for heating; use of high temperature steam for building heating; vacuum returns system; flow diagram of equipment in heating returns pit; temperature control; salvaging of old equipment.

Saves 16% Fuel by Modernizing Apartment Heating, by R. C. Nason.
Vol. 8, No. 4. April, 1936. p. 195.
High fuel costs in apartment building because of excessive draft; automatic smoke breeching damper installed; coal consumption reduced, other advantages.

Sixty Gas Fired Units Heat Pier Exhibit Space.
Vol. 8, No. 4. April, 1936. p. 202.
One of largest unobstructed exhibit spaces in world—Chicago's Navy Pier—heated by gas fire unit heaters; rating and installation of units; design conditions; supplying and metering gas; photograph of installation of pressure regulators.

The Nemours Carillon Tower, by Lee P. Hynes.
Vol. 8, No. 10. October, 1936. p. 536.
Description of Nemours Carillon Tower, Wilmington, Del.; electricity used for heating; unique heating problems involved; special insulation treatment; dew point control prevents condensation in substation room; flood lighting; lightning protection; electrical operation of bells; views of interior and electrical equipment.

To Modernize with New Central Heating Plant.
Vol. 8, No. 2. February, 1936. p. 98 (back section).
Answer to reader's question by Samuel R. Lewis; recommendations for design and layout of central heating system for university.

Trapping and Venting Blast Coils.
Vol. 8, No. 10. October, 1936. p. 116 (back section).
Answer to reader's question by Samuel R. Lewis; recommendations for trapping and venting blast coils.

Trouble-Shooting—Bringing Back the Missing Water Line, by H. G. Schaefer.
Vol. 8, No. 1. January, 1936. p. 11.
Zoned heating system under thermostatic control for heating parochial school and church; steam condensing in zone system created vacuum, causing boiler water line to drop; trouble overcome by installing vacuum breaker in main.

Unit Heating and Cooling, by Samuel R. Lewis.
Vol. 8, No. 11. November, 1936. p. 587.
Comparison of power requirements for central blast heating system and unit heating system; control of unit heating and ventilating systems; recirculating unit heaters; cooling with units; location of unit heaters; air velocity; steam pressure.

What the Operating Engineer Should Know About the Combustion Process and Boiler Efficiency, by Paul R. Unger and Kalman Steiner.
Vol. 8, No. 7. July, 1936. p. 361.
Combustion processes illustrated; hypothetical volume of air entering firebox, participating in combustion, and emerging as flue gas; oxygen, nitrogen, hydrogen, carbon dioxide; flue gas analysis and its use; checking combustion process; average stack loss for various percentages of carbon dioxide and various stack temperatures for bituminous coal, fuel oil and natural gas; importance of correct mixture of fuel and air.

Piping

Alloy Steels for Welded Power Piping, by J. R. Dawson.
Vol. 8, No. 8. August, 1936. p. 435.
Abstract of paper presented at Midwest Power Engineering Conference; choice of materials; creep strength; corrosion resistance; corrosion in valve parts; welding alloy steels; alloys most useful in steel; low chromium and high chromium steels and their uses; metallurgical considerations in welding.

Condensate Removal from Cooking Kettles, by John W. Hieronymus.
Vol. 8, No. 4. April, 1936. p. 205.
Cooking time and steam consumption reduced by proper trap selection and piping; test data on consumption and condensate removal from cooking kettles; diagram of test set-up; sizing supply and condensate piping; air removal imperative; steam loss with cracked valve; steam requirements of kettles; tables of temperature reduction caused by air at various pressures, cost of steam leaks, steam condensed per sq ft of jacketed kettle condensing surface, and steam condensing area of kettles.

Conserves Compressed Air for Sewage Ejection by Taking Tip from Ancient Greek (Practical Piping Problems), by H. G. Schaefer.
Vol. 8, No. 5. May, 1936. p. 254.
Conservation of compressed air for sewage equipment; diagram and explanation of piping layout used; method of operation.

Correcting Flow Meter Readings, by William Goodman.
Vol. 8, No. 11. November, 1936. p. 592.
Principle of flow meter operation; correcting for pressure changes; correcting for steam quality and superheat; plant alterations cause meter errors; example.

Design of Modern Industrial Piping Systems—Support of Pipe Lines, by F. L. Snyder and T. E. Bridge.
Vol. 8, No. 2. February, 1936. p. 93.
Simplified method for determining location of pipe supports; design of spring hangers; distance between supports; spring design data tabulated; table of properties of pipe; nomograph for deflection of pipe between supports; nomograph for fiber stress in pipe walls due to internal pressure; graph of modulus of elasticity, allowable fiber stress, and thermal expansion of pipes; table of weight of pipe insulation per foot; example shows use of data; suggested designs and dimensions for hangers and supports.

Design of Modern Industrial Piping Systems—Support of Pipe Lines, by F. L. Snyder and T. E. Bridge.
Vol. 8, No. 4. April, 1936. p. 189.
Simplified method of designing supporting columns for pipe lines; advantages of circular cross-section; foundations; step-by-step example of design of supports showing use of data presented; example showing design of foundations; charts for design of columns and foundations; photographs of supports designed by method given.

Distillery Piping Requirements—and How They Were Met at the World's Largest Distillery, by B. C. Stewart.
Vol. 8, No. 5. May, 1936. p. 249.
New plant of Hiram Walker & Sons, Peoria, Ill., the distillery process; service piping systems—water, gas, hot water, steam; process piping systems—grain, meal, mash, yeast, beer, slop, concentrated slop, carbon dioxide, distilled water, alcohol, industrial alcohol, fusel oil and aldehydes; table of piping services, piping materials, and maximum diameters of lines; photographs of equipment.

Estimating Piping—Method Outlined, Principles Explained, by E. W. Norris.
Vol. 8, No. 1. January, 1936. p. 19.
Importance of the estimate; the various items—plan, list of

material and costs, cost of labor; example of estimate of turbine lead shows use of suggestions given; method the same for larger jobs.

Estimating Piping—Preparation of Sketches, by E. W. Norris.
Vol. 8, No. 3. March, 1936. p. 151.
Preparation of sketches for estimating and as preliminary to formal plans and specifications; flow diagram an effective tool; valve location; size of lines; providing for flexibility; selecting classes of material to be used.

Expansion of Jacketed Pipe Line.
Vol. 8, No. 1. January, 1936. p. 24.
Answer to reader's question on article by G. W. Hauck, November, 1935, issue; construction of jacketed piping; no trouble from unequal expansion with method used.

Field Tests Check Analyses of Stresses and Change of Shape in Expansion Bend, by E. A. Wert and S. Smith.
Vol. 8, No. 12. December, 1936. p. 661.
Main steam cross-over of unusual length in the form of a large expansion bend installed at Conners Creek power plant; limited space available required analysis of expansion movement; designing for flexibility; movement of the structure; grapho-analytical analysis; movement tested after erection; supporting the line; anchors incorporate rolling feature; selecting shape of the pipe structure; necessity of analyzing change of shape of pipe line in travelling from cold to hot position; comparison of theoretical and actual movements; diagrams and illustrations of line.

Flanged Piping Joints—Methods for Applying and Determining Bolt Stresses, by E. C. Petrie.
Vol. 8, No. 6. June, 1936. p. 303.
Pressure retaining efficiency of a bolted flanged connection; tests made; bolting materials; instrument for measuring bolt elongation; methods for determining bolt loads — torque method, elongation method; test set-up for 20 in., 1500 lb cast steel flanged joint; data for practical application of bolt loads; method of inducing bolt elongation by heat; application of torque method; torque-stress relationship tests; effect of thread lubrication; effect of thread form; test results, torque-strain relationship, alloy steel bolts; torque-size relationship, coarse thread and alloy steel bolts; tables of torque-stress relationships and foot-pounds to produce given stress in alloy steel and coarse thread bolts.

Friction Effect of Slip Joints, Rollers and Guides on Long Steam Transmission Pipe Lines.
Vol. 8, No. 7. July, 1936. p. 372.
Results of investigation on 8,000 ft, 12 in. main; expansion of piping; coefficients for metals used in pipe.

Fundamentals of Joint Design for Welded Piping Systems, by S. C. Clark.
Vol. 8, No. 10. October, 1936. p. 552.
The butt type weld; requirements in weld design; angle of bevel; joint spacing; tack welds; weld cross-section; inside and outside corner welds; fillet welds.

Fusion Welded Power Piping, by W. D. Halsey.
Vol. 8, No. 12. December, 1936. p. 647.
Paper presented at annual meeting of *International Acetylene Association;* quality of welding for high pressure piping; requirements of *A.S.M.E.* code; X-ray examination; stress relieving; new inspection procedure for pipe lines adopted by Hartford Steam Boiler Inspection and Insurance Co.; test specimens and qualification of welders; standards for welded joints; defects; encouraging operator to do his best work.

Holding Properties of Gaskets Studied. Translation and discussion by F. E. Wertheim.
Vol. 8, No. 7. July, 1936. p. 367.
Translation of report of German investigation; gaskets tested hydrostatically and under steam pressure; test set-up; results of tests on metallic and non-metallic gasket materials; discussion by translator; use of various gasket materials.

How to Design Steam Piping for Maximum Capacity and High Pressure Drop, by Max W. Benjamin.
Vol. 8, No. 9. September, 1936. p. 475.
Phenomenon of acoustic velocity; limit imposed on capacity of pipe line; two classes of service where acoustic velocity limit occurs; restricted application of usual formulas for pressure loss in piping; behavior of gases and vapors having adiabatic exponent greater than unity illustrated; exponents of substances; diagrams showing relationships between pressure drop, length of pipe line, and weight of flow for steam; approximate values of acoustic velocities for steam; example of design of exhaust line from turbine to condenser illustrates use of the data; note by Sabin Crocker on use of the information.

How to Make a Pipe Templet, by S. C. Clark.
Vol. 8, No. 7. July, 1936. p. 384.
Layout of mitered joints for direction changes in 200 ft, 20 in. oxy-acetylene welded pipe line; instructions for making templet; cutting the pipe.

Method of Designing a Heat Exchanger, by T. J. Kauders.
Vol. 8, No. 10. October, 1936. p. 548.
Design of pit type heat exchanger or reclaimer worked out in detail; calculations for amount of heat exchange surface.

Multi-Layer Oxy-Acetylene Pipe Welding, by R. M. Rooke and F. C. Saacke.
Vol. 8, No. 11. November, 1936. p. 613.
Paper presented at *American Welding Society's* annual meeting; advantages of multi-layer welding; comparison of weld metal cross-sections; process of making a three-layer rolling pipe weld; shape of the layers; welding technique; tests of multi-layer welds; recommended number of layers.

Multi-Layer Oxy-Acetylene Pipe Welding, by Arthur N. Kugler.
Vol. 8, No. 12. December, 1936. p. 677.
(Part 2); paper presented at *American Welding Society* annual meeting; use of multi-layer welding; description of welding of two power piping installations; qualifying operators; reduced section tensile tests; free bend tests; nick break tests; reverse bend tests; test data tabulated; merits of multi-layer welding; recommended procedure for various pipe wall thicknesses.

Piping and Pumping Process Materials, by Lee P. Hynes and Charles D. Campbell, Jr.
Vol. 8, No. 1. January, 1936. p. 3.
Requirements for piping various process materials; molasses and similar syrups; unloading molasses from cargo steamers; waxes, resins, and shellacs; gas impregnated materials handled at sub-zero temperatures; horsepower and discharge pressures; installation of pumps and piping; cold weather precautions; conversion table; oil measurement table at 60 F.

Piping at Boulder Dam, by Carleton W. Campbell.
Vol. 8, No. 4. April, 1936. p. 200.
Size of the project; penstock system; power house piping; cooling water system for generators; penstock details.

Piping Plays Important Part at Schrafft's, by L. P. Leathers, with Francis A. Westbrook.
Vol. 8, No. 12. December, 1936. p. 654.
Description of piping at W. F. Schrafft & Sons Corp. plant, Boston, Mass.; chilled water piping for air conditioning; water tested and treated to prevent corrosion and clogging of nozzles; brass pipe headers; nozzle openings tested with plug gauge; piping requirements for melted chocolate and corn syrup; screwed wrought iron pipe used for plumbing lines; insulation of the piping; method of conserving process water.

Piping Slurry and Cement at a Modern Mill, by Ralph H. Butz.
Vol. 8, No. 8. August, 1936. p. 442.
Slurry and cement piping at National Portland Cement Co., Brodhead, Pa.; process explained; layout of piping.

Plant Adopts Piping Identification Scheme, by W. W. Watkins.
Vol. 8, No. 6. June, 1936. p. 319.
Scheme of piping identification adopted by rubber products plant; instructions for painting piping, valves, and fittings.

Power Piping Requirements, by J. Roy Tanner.
Vol. 8, No. 7. July, 1936. p. 388.
Abstract of paper presented at Midwest Power Engineering Conference; use of welding; fabricated piping; standardization; compensating for loss of strength where pipe walls are cut for branches.

Power Plant Piping.
Vol. 8, No. 10. October, 1936. p. 547.
Creep; use of alloy steels; hard facing valves.

Practical Piping Problems—How to Select a Pump for Evacuating a Tank, by S. B. Redfield.
Vol. 8, No. 3. March, 1936. p. 141.
Method of selecting pumping equipment for evacuating a tank, as required in various process industries; what is required of the vacuum pump; step-by-step solution of the problem explained; assumed characteristics of pump used in example; time curve; selecting pump to evacuate tank in a given time; handy guide for estimating time required to evacuate tank and selecting pump.

Solving Stresses in Piping Offsets Subject to Compressive Load from an Expansion Joint, by A. R. Pettit.
Vol. 8, No. 8. August, 1936. p. 423.
Exact calculation of stresses in piping offsets tedious; short method of calculation offered; typical example calculated by short method and by grapho-analytical method; comparison of results.

Strength and Design of Covers and Flanges for Pressure Vessels and Piping, by T. McLean Jasper, H. Gregersen, and A. M. Zoellner.
Vol. 8, No. 11. November, 1936. p. 605.
(Part 1); investigation establishes methods for design of covers and flanges; covers; ring flanges; comparison between results obtained from formulas and plaster of paris test flanges; variation of external moment with flange thickness; variation of external moment with flange width; test points and theoretical curves plotted.

Strength and Design of Covers and Flanges for Pressure Vessels and Piping, by T. McLean Jasper, H. Gregersen, and A. M. Zoellner.
Vol. 8, No. 12. December, 1936. p. 672.
(Part 2); hubbed flanges; formulas for design; fillet coefficients.

Table of Properties Aids Piping Design, by F. L. Snyder.
Vol. 8, No. 6. June, 1936. p. 328.
Properties of pipe, sizes 14 in. to 36 in. O. D.; explanation of use.

Table of Properties of Pipe Aids Piping Design, by F. L. Snyder.
Vol. 8, No. 5. May, 1936. p. 258.
Properties of pipe, sizes ⅛ to 12 in.; explanation of use.

Underground Piping for Central Refrigeration Service, by R. H. Switzler.
Vol. 8, No. 7. July, 1936. p. 380.
Abstract of paper presented at International Congress of Refrigeration; history of central refrigeration in St. Louis; construction features of pipe line; operating problems encountered; direct expansion system compared with brine circulating system.

Use of American Standard Pipe Thickness Schedules, by Arthur McCutchan.
Vol. 8, No. 10. October, 1936. p. 531.
(Part 1); American Standard for Wrought Iron and Wrought Steel Pipe approved November, 1935; purpose of standard; schedule numbers; pipe wall thicknesses; allowances for threading, mechanical strength and/or corrosion; allowable *S* values for steel pipe; example shows selection of pipe thickness schedule; table of properties of pipe for Schedules 10, 20, 30 and 40.

Use of American Standard Pipe Thickness Schedules, by Arthur McCutchan.
Vol. 8, No. 11. November, 1936. p. 595.
(Part 2); significance of ratio of working pressure to allowable stress in selecting pipe wall thicknesses; tables of properties of pipe for Schedules 60, 80, 100, 120, 140, 160 pipe; significance and use of the properties tabulated.

Valve Design and Construction for High Pressure Piping, by H. H. MacMillen.
Vol. 8, No. 5. May, 1936. p. 265.
(Presented at Midwest Power Engineering Conference, Chicago, April, 1936); description of Port Washington Station, Milwaukee, Wis.; location of valves; drain lines, exhaust header, auxiliary piping; materials of valve construction; piping, flanges, and bolting; cross-section of 18 in., 600 lb gate valve.

Welding Lead Sheets and Pipe, by F. E. Rogers.
Vol. 8, No. 9. September, 1936. p. 487.
Applications of lead burning or welding of lead with a gas torch; applying linings to tanks; chemical lead; antimonial lead; cleaning, preparation and forms of joints; how joints are made and welded; torches and gases; weight of lead and sizes of burning bars; lead pipe welding; lead pipe sizes used in chemical plants; illustrations showing proper methods of preparing and making welds.

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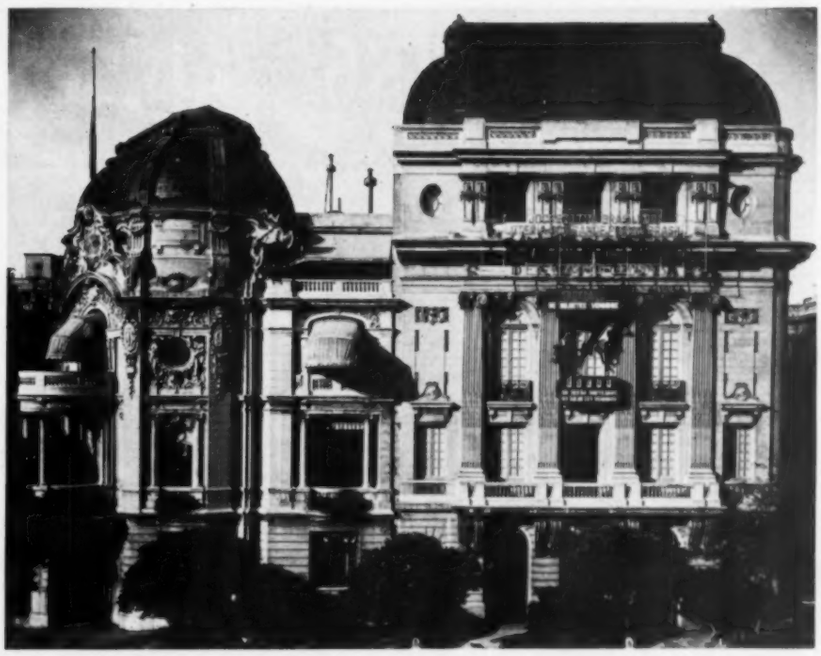
Xmas Heat Wave hits Rio



(Above) Baker equipment was selected for the air conditioning system in this office building in Rio de Janeiro.

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(Right) Studios of Radio Station PRF-4, Baker air conditioned. All Rio de Janeiro installations by Ceibrasil Representacoes, Ltda., Engineers.

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Booklets, Reports and Papers

Air Conditioning and the Gas Industry

The process and comfort air conditioning committee report was presented by L. A. Bickel, of the Dallas Gas Co., chairman, at the *American Gas Association's* annual convention, at Atlantic City, N. J., October 26-30.

The two essential functions of summer air conditioning are (1) dehumidification (drying) and (2) cooling of the air, he said. These functions may be produced by any of the following gas-operated combinations: (1) Adsorption type dehumidifier, and tap water for cooling (where the water is cold enough and cheap enough), (2) adsorption type dehumidifier and gas engine powered refrigerating compressor unit for cooling, (3) gas engine powered refrigerating compressor unit for both dehumidification and cooling.

There are at least three highly developed and dependable gas-operated dehumidifiers on the market at the present time. For refrigeration and cooling, a seven ton capacity completely automatic gas engine compressor unit has been developed. This unit has proved successful on railway cars which used bottled gas, in restaurants, beauty shops, and other similar commercial installations using city gas. Completely automatic gas engine power units for furnishing motive power for the mechanical refrigeration compressor of any manufacturer will, it is expected, be available in any capacity and any size next year. These units will simply replace electric motors for driving conventional refrigerating or air conditioning systems. For larger installations, where an engineer is in attendance and fully automatic control is not required, gas engines of any make can be belted or direct connected to mechanical compressors.

An appendix to the report included a report on gas process air conditioning for 1936, by Charles W. Swenson, Consolidated Edison Co. of New York; installations used for air conditioning industrial processes, by G. L. Simpson, Pittsburgh Lectrodryer Corp.; dehumidification by gas heat energy, by James C. Patterson, Bryant Heater Co.; gas fuel engines, by L. W. Melcher, Waukesha Motor Co.; and a study of various combination systems, by L. Ourusóff, Washington Gas Light Co. Mr. Swenson reported that according to information furnished by two manufacturers of gas operated summer air conditioning equipment, there were (up to the date of report) 29 installations of dehydration units throughout the country in 13 different industries, representing a total tonnage capacity of 115 and a rated gas consumption of 38.40 therms per hour.

Mr. Swenson also presented a report which was a recapitulation of the progress made in applying summer gas air conditioning to industrial plants, and in which was given information on the requirements of air conditioning for various industries. For years, the gas industry has been meeting the various problems of drying and processing by the use of well designed gas appliances, he said. In most cases, the processing was such that the circulation of heated air, automatically controlled was sufficient.

There are, however, some drying processes which cannot be met by the usual warm air appliances because low temperatures as well as low humidities are required for their most favorable performance. In such processes, the temperature must be kept constantly at a relatively low figure to prevent physical or chemical changes which might result in injury to the product. This is especially true in the handling of hygroscopic materials, such as paper, film, chemicals, drugs, etc., where the relative humidity and temperature have a marked influence on the rate of production, general quality and appearance of the product. It is most important that the moisture content of the air be maintained at a figure favorable to rapid and satisfactory process-

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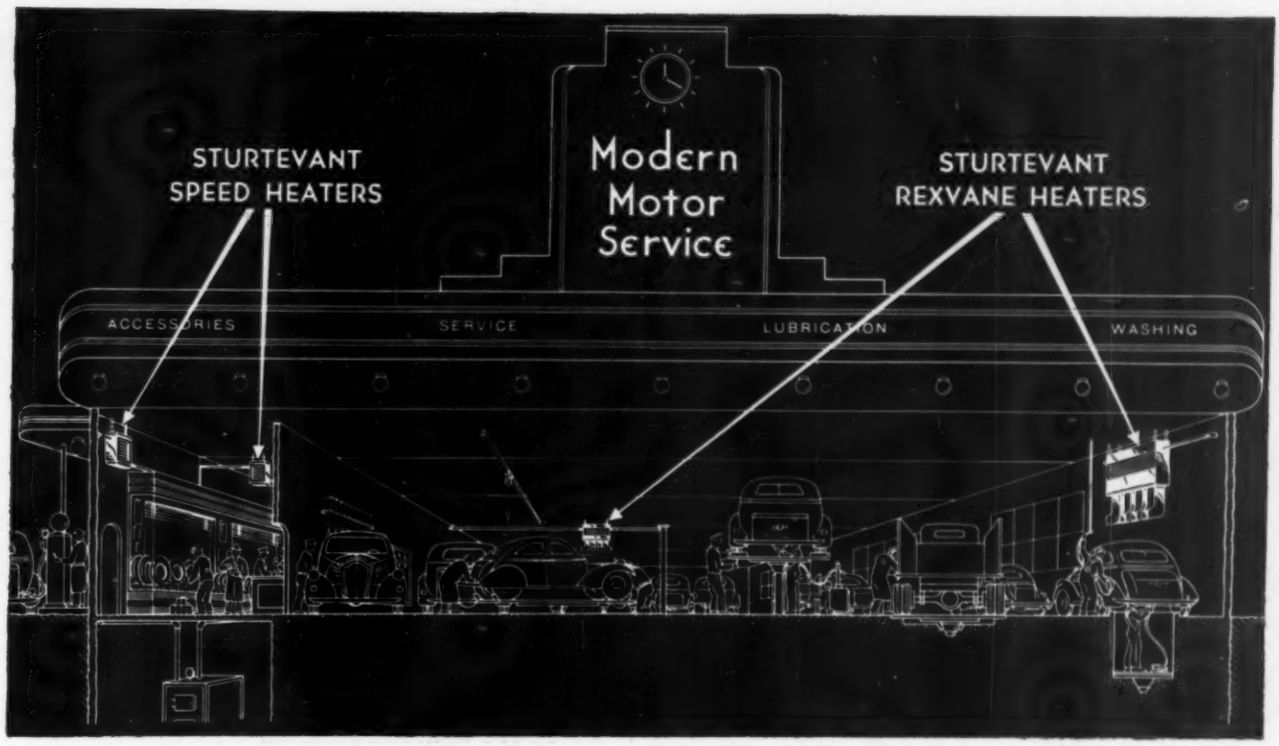

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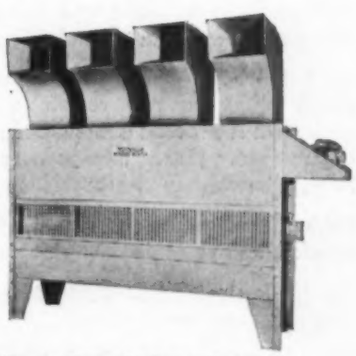

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ing, thus keeping losses at a minimum. With this uniform condition, independent of the outside atmospheric elements, high speed machinery can be adjusted for maximum production with a minimum of delay, spoilage and defective products. To meet these problems of indoor atmosphere control, the gas industry has designed special drying machines, namely, the gas-operated dehumidifiers.

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Coal and Coke Standards

The *American Society for Testing Materials,* through the work of its committee on coal and coke, has issued 24 standard specifications and methods of testing coal and coke. This compilation gives all of the *A.S.T.M.* coal and coke standards in their latest approved form. Methods are given for sampling, sieve and screen analysis, designating size, and tests cover fineness, grindability, cubic foot weight, shatter, etc. Specifications cover gas and coking coals, foundry coke, sieves and screens for testing, and classification of coals by rank and by grade.

Copies of this 145 page publication are available at $1.25 each from the *A.S.T.M.,* 260 S. Broad St., Philadelphia, Pa.

Hospital Air Conditioning Committee Reports

American hospitals are likely to invest, eventually, millions of dollars to secure conditioned air, assuming improved equipment at lower cost, according to the 1936 report of the committee on air conditioning of the *American Hospital Association.* The report is based upon a questionnaire, replies to which were received from 48 hospitals having air conditioning equipment actually installed and others contemplating air conditioning. The committee believes that the number of hospitals employing air conditioning is still small, possibly not exceeding 200-300 hospitals.

On the basis of the answers, cooling was found to be the air conditioning function most widely used, followed in order by dehumidification, filtration, and humidification. As would naturally be expected, air conditioning is going forward much more rapidly in the southern and southwestern hospitals, it is stated. While little data were obtained on the use of conditioned air as a therapeutic or preventive agent, definitely favorable results were reported in asthma cases, respiratory infections, sinusitis, cardiac conditions, prematurity, and progress of postoperative patients. Only one correspondent expressed disappointment with air conditioning, referring to an unsatisfactory experience with a single room unit. The committee feels that the studies should be continued next year, and is particularly desirous of obtaining information on conditioned air in the case of tuberculosis.

Published by the *American Hospital Association,* 18 E. Division St., Chicago, Ill., as Bulletin 139, the report is eight pages in length; price is 50c. The committee membership comprises C. W. Munger, M. D., chairman; Mary V. Stevenson, R. N.; Perry W. Swern, Hospital Architect; and Lucius R. Wilson, M. D.

The Professional Engineer

The Russell Sage Foundation, 130 E. 22nd St., New York, N. Y., has published an 86 page booklet "The Professional Engineer," by Esther Lucile Brown of the department of statistics of the Foundation. It is one of a proposed series of monographs dealing with the present status of certain established or emerging professions in the United States. Its price is 75c.

The engineer and engineering teacher will find this discussion not only of professional interest, but of personal interest as well. Engineering education and the evolution of engineering colleges and technical schools other than engineering colleges are first reviewed, the number and nature of national associations are

Reprinted from
The Modern Hospital
It was the Summer of 1927. To do homage to Charles Lindbergh, a throng of the great and near-great was gathered in the banquet hall of a New York hotel. Toast upon toast, eulogy upon eulogy, were tendered the returned hero—the solo flier who had just conquered the Atlantic.
Almost unnoticed at the speaker's table sat another Charles . . . Charles Lawrance, President of Wright Aeronautical Corp., designer and builder of the Wright Whirlwind motor whose ceaseless beating had carried Lindbergh to Paris in 33 hours.
At length a friend at his side spoke to Lawrance. "Charley," he said, "what are you thinking as you sit here in the midst of this adulation of the man who did the flying? Why is there so little thought of you, who, with your years of work, gave him the motor that made his flight possible?"
Lawrance paused. Then in his succinct way he answered,
"Who ever heard the name of Paul Revere's horse?"

The name of Paul Revere's horse was "DOBBIN"

And he wasn't a blooded Arabian . . . just a plain work horse. Of course he never got the credit he deserved. You can't cut fame up into little pieces and pass it around to everybody who shared in the job. Most of us are only too glad to do our part because it's the way we earn our oats, and . . . well we get a kick out of doing it right.

If you have a manufacturing problem that involves metallurgical research . . . whether you're creating a complete air-conditioning line or selling a better humidifying gadget . . . you'll find the Revere Technical Advisory Service only too ready to work its head off in developing just the right copper alloy and helping your plant find the best way to fabricate it. And when the job is done, we won't ask to share the glory. That is one thing we got from Paul Revere's horse.

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THE only complete small steam trap—Super-Silvertop No. 10 leads the field after being on the market only three months (following one year in the laboratory and two years in the field). Users of small steam traps needed a trap that was positive in action, one that would keep steam units drained dry. Being an inverted bucket trap, Super-Silvertop No. 10 meets this need. It has all the advantages of the larger Super-Silvertop traps, but its size and price make its use feasible for *any* job requiring a small trap. Super-Silvertop No. 10 puts an end to parts replacement, its inverted bucket will not collapse or leak regardless of pressure. It has the same pipe connections as thermostatic traps, which means that it can replace thermostatic traps without change of piping. For pressures from 0 to 125 pounds. Write for table of capacities and other information.

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considered and several examples of such associations are given, the number of engineers and the demand for their services are investigated, and four studies on the salaries of engineers are summarized. The concluding section is devoted to trends in engineering.

Fuel Engineers Discuss Smoke Abatement

Improved smoke abatement practice through better combustion was the theme of the 16th fuel engineers' meeting sponsored by the fuel engineering division of Appalachian Coals, Inc., at Cincinnati, October 5. A limited number of copies of the proceedings of the meeting are available at no charge from the sponsor, whose address is Transportation Bldg., Cincinnati, Ohio.

The proceedings should prove valuable as a reference book for fuel and smoke abatement engineers. Contents include discussions of the coal man's responsibility for better combustion and less atmospheric pollution; smoke abatement in coal burning plants; sulphur, the destroyer; air pollution tonnage; improving combustion practice; and smoke—contributing factors and methods of correction for industrial underfeed stokers, pulverizers, spreader stokers, residential stokers, domestic hand-fired furnaces, industrial and commercial hand-fired furnaces, locomotives, chain grate stokers, and marine boilers. Introductory and supplementary remarks are also included.

I. A. A. Hears Papers on Pipe Welding

Several papers on welding piping were presented at the annual convention of the *International Acetylene Association*, 30 E. 42nd St., New York, N. Y., at St. Louis last month. That by Wm. D. Halsey appears elsewhere in this issue.

W. A. Benoist, Assistant Engineer, Anheuser-Busch, Inc., discussed the advantages of welded or "streamlined" power plant piping, and stated that the economies in favor of welding increase with the size and weight of the pipe. Savings arise because of several factors, he said, which include thinner wall pipe, elimination of threading operations, lower cost of beveled end pipe for welding, reduced weight of welding fittings, ease of insulating, and others. At the present time, all piping over 2 in. is welded at Anheuser-Busch.

Sherman T. Seeley, Midwest Piping & Supply Co., spoke on why the piping contractor should recommend welding to architects and engineers. He stated that in central station design engineers are realizing more and more the importance of treating their piping problems with the same infinite consideration and caution they have always given the other equipment, discussed the advantages of shop welding over field welding, and compared costs of flanged and welded assemblies. He pointed out that the "complete elimination" of the flanged or screwed joint has not and probably never will be accomplished, and gave specific recommendations for many services, including chilled water piping for air conditioning, for which prefabricated and field welded construction has outstanding merits, he believes.

Progress in oxy-acetylene pipeline welding was described by T. R. Jones, President, T. R. Jones, Inc. He introduced his subject by remarking on the early days when almost anything, including bailing wire, was used as welding rod and when it was felt that the more rod that could be piled into a joint, the better and stronger it would be; some of this first welding came to be known as "collar" welding because so much metal was piled up outside the joint it looked like a collar. He then discussed current field welding practice, pipeline organization and the duties of the line up gang, firing line—or welding gang—, and the laying gang, speed of welding, joint design, pipe material, etc.

Oxy-acetylene welding in the operation and maintenance of pipelines was the subject of R. P. Gonzales, Assistant Superintendent, Pipeline Division, Arkansas Louisiana Gas Co. He described in a general way the use of welding and cutting equipment in the maintenance of gathering lines, compressor

stations, main lines, and distribution lines. It is often found profitable to salvage, by welding into standard lengths, short pieces of pipe no longer than 30 in., he stated, the work being done by the main line maintenance crews while being held at their stations ready for emergency, as they are (particularly in severe weather) to assure that the line will be kept in continuous service.

The Editor's Page—

(*Continued from page* 33, *front section*)

last month. His paper provoked lively discussion. . . . Even the American Society of Agricultural Engineers is devoting attention to air conditioning. The program for their Chicago meeting includes a paper on engineering problems in air conditioning, by Mr. Lewis; a paper on the measurement of air conditions in farm homes; and a discussion on insulation. . . . A. F. Hoesel, Peerless Ice Machine Co., discussed the elements of figuring an air conditioning job at the Refrigeration Service Engineers' Society meeting at Memphis last month. He outlined and discussed the factors to be considered in the calculation of heat load—transmission gain, sunlight gain, occupancy, electric load, appliance load, and outside air heat gain.

■ **"I find** articles on air conditioning plants of great interest," says A. C. Standish Bennett of The Imperial Tobacco Co., Liverpool, England. "Rush D. Touton's articles are most helpful. My copies of HEATING, PIPING AND AIR CONDITIONING have been read by a number of business friends, all of whom are most impressed with it."

Book Reviews

Ventilation of Ships

"The Ventilation of Ships," by F. L. Bullen, M. Inst. N. A. Published by Charles Birchall & Sons, Ltd., 17 James St., Liverpool, England. 2nd ed., 1936, 154 *pp.,* 7 *x* 9½ *in., clothbound. Price,* 7*s,* 6*d.*

This book, the first edition of which appeared February, 1935, is the outcome of his early efforts when engaged on ship construction and design to understand the principles and practice of ventilation of sea-going vessels, the author says in his preface.

The first chapter is a brief discussion of the properties of air, the second of ventilation requirements, the third of methods of ventilating, and the fourth of ventilator heads. Chapter 5 is a more extended treatment of fans, and Chapter 6 ("Air Trunks") includes information on duct design and air flow of general application.

The next four chapters are concerned with the requirements of cargo spaces, machinery spaces, crew's quarters, and passenger accommodations. Heating and cooling, and air conditioning, are then considered and the concluding chapter is devoted to testing ventilation systems. An appendix gives definitions of terms and miscellaneous data and formulas.

Arc Welding Manual

*"Arc Welding Manual and Operator's Training Course," by W. J. Chaffee. Published by The Hobart Brothers Co., Box FW*116, *Troy, Ohio. 2nd ed.,* 1936, 94 *pp.,* 5½ *x* 8 *in., fabricoid binding. List price,* $1.00; *available to readers for* 75*c in stamps.*

This practical little pocket-size book on arc welding presents the subject in non-technical manner, as it is intended to be as

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useful to the beginner as to the experienced operator and technician. Included are a discussion of the welding arc, welding equipment, weldability of metals, types of joints and welds, weld strength, speed and cost of welding, using the metallic arc, and welding with bare and coated electrodes. Twenty-five exercises for training operators are given.

Wrought Iron

"Wrought Iron—Its Manufacture, Characteristics, and Applications," by James Aston, Consulting Metallurgist, A. M. Byers Co., and Edward B. Story, Chief Metallurgist, A. M. Byers Co. Published by A. M. Byers Co., Pittsburgh, Pa. 1st ed., 1936, 59 pp., 6x9 in., clothbound. Price, $1.00; available gratis to readers upon request on business letterhead.

This handbook has been written and published to answer the need for easily available information on the qualities and applications of wrought iron. It is intended to serve as a source of up-to-date data for engineers, architects, and others who have occasion to specify or use wrought iron; students taking technical courses in universities and colleges; and the general reader interested in ferrous metals.

Early methods of manufacture and early scientific research in wrought iron manufacture are first described, followed by a chapter on present-day manufacturing methods in which is described the Byers process. The next chapter is devoted to the development of other ductile ferrous metals.

The fifth and sixth chapters take up quality standards for, and characteristics of, wrought iron, and are followed by a chapter outlining the principal applications of this material. The concluding chapter is a brief discussion of material selection and the factors that must be taken into account.

A glossary of terms relating to wrought iron manufacture and products is included, and numerous photographs are shown.

How to Avoid Trouble from Noise in Air Conditioning Installations

THE EDITOR—The article by P. H. Geiger "How to Avoid Trouble from Noise in Air Conditioning Installations" in the November issue interests me very much because the data presented seem to be of definite practical value. There are some points, however, which I am afraid I do not understand, and an explanation would be very much appreciated.

I am under the impression that it should be possible to derive, from Figs. 3 and 4, the values plotted in Fig. 5. It is my understanding that for a Type B grille at any given face velocity and area the loudness level as derived from Fig. 3 and corrected by Fig. 4, should check with the values shown in Fig. 5.

Referring to Fig. 6, the impression I gained is that the loudness level of a grille as derived from Fig. 3 is increased when a room contains a large number of absorption units, but is decreased if a room contains a small number of absorption units. As this understanding is entirely opposite to experience, I can only conclude that I am not reading the curve correctly. Further explanation on the points mentioned would be very greatly appreciated.—DIRECTOR OF ENGINEERING.

REPLY—In regard to your inquiry, the values of Fig. 5 can not be obtained from Figs. 3 and 4 unless the free area of the grille is known. Actually the data for Fig. 5 were obtained from a curve giving loudness level as a function of volume air flow. This curve was not submitted for publication in order to keep within the space requirements. It was thought that Fig. 3 would be more useful.

The algebraic signs of Fig. 6 are obviously incorrect; the correction as given by the curve should be subtracted instead of added. I am indeed very sorry that this error crept by me. —P. H. GEIGER.

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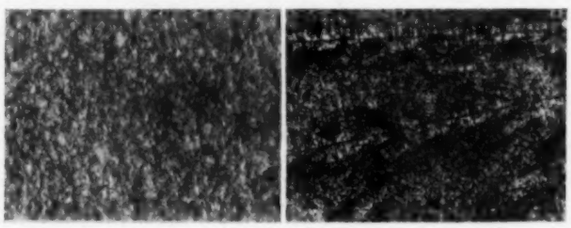
Equipment Developments

For your convenience in obtaining more information about any of this equipment, see coupon on page 142. Add the new products and companies listed here to your Directory Section which you received in your January 1936 HEATING, PIPING AND AIR CONDITIONING and thus keep your records of sources of supply up to date throughout the year . . . Single asterisk (*) indicates equipment not listed in Directory Section; double asterisk (**) equipment and manufacturer not listed.

New Galvanized Sheets Assure Good Paint Bond

No. 1124—Commercial production of a new kind of galvanized sheet ("Armco Galvanized Paintgrip") that assures a good paint bond on iron and steel products has been announced, following several years of intensive research. These sheets, the manufacturer says, are chemically treated to produce a finely crystalline phosphate coating which in itself is neutral to paint, being neither acid nor alkaline, and keeps the paint from direct contact with the zinc surface. This coating is an integral part of the sheet and is slightly granular in nature.

The illustration shows one of the new sheets at the left and an ordinary sheet at the right.



Available in any of the grades of galvanized sheets manufactured by the maker. Analysis of the base metal can be that of "Armco Ingot Iron," plain or copper-bearing steel. When required, all grades of these sheets can be supplied stretcher leveled.—The American Rolling Mill Co., 703 Curtis Ave., Middletown, Ohio.

Small Trap for High Pressure Drips

No. 1125—New forged steel trap has been designed to fill the need for a small, relatively low-priced trap to take care of high pressure drips at pressures up to 450 lb ga. It is provided with either ½ or ¾-in. screwed or flanged connections.

The inverted bucket and free floating lever operating principles are used. There are but two moving parts—the bucket and the valve lever assembly. The complete interior mechanism is made of stainless steel, the valves and seats being heat treated for maximum hardness and toughness. The body and cap are forged from *S.A.E.* 0.25 to 0.30 steel and the bolts and nuts are made from "Supertemp" steel.

The trap weighs approximately 30 lb and is 10¼ in. high by 6¾ in. in diameter. At 450 lb operating pressure it has a continuous discharge capacity of approximately 2500 lb per hr of hot condensate, states the maker. —Armstrong Machine Works, 874 Maple St., Three Rivers, Mich.

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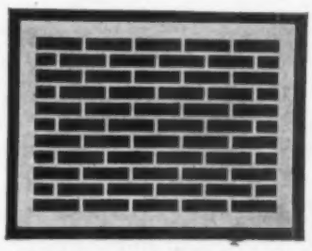
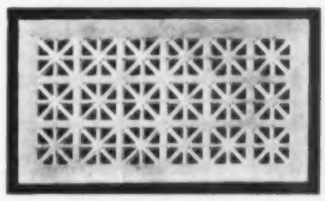
AUER Stamped Metal Grilles come in a wide range of decorative designs. They can be supplied to suit any individual requirements as to size and shape, and to harmonize with any particular interior architectural treatment. Steel, stainless steel, brass, or bronze—in standard or special finishes. For vents, radiator enclosures or any other purpose, bear in mind that Auer Grilles have all the qualities of beauty and durability which you have learned to expect from Auer Products.

Complete catalog of Auer Registers and Grilles sent promptly on request.



No. 37A — A New and DIFFERENT Design, with Generous Free Area



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Known Wherever Refrigerants Are Controlled

New Valve Regulates and Balances Radiators

No. 1126—The new regulating valve illustrated is not only a radiator valve but is also an adjustable regulating plate as well. It provides means to change the size of the orifice without disconnecting the radiator. Used with the "Dunham Differential" vacuum heating system, which circulates sub-atmospheric steam of varying temperatures, it permits balancing and regulating individual radiators. A raised cap contains the adjusting mechanism which is thus out of the steam flow. It also prevents tampering by unauthorized persons, but is accessible to those authorized.

The bellows diaphragm construction makes the valve packless and leakproof, states the maker, who says that neither steam, air, water nor sediment can come in contact with the adjusting and operating mechanisms, which therefore operate freely. The expansion member, of tinned phosphor bronze, is built so that the movement is spread over corrugations on the flat sides instead of at the edges to insure maximum resiliency and wear.

Valve is adaptable to existing heating systems where heating satisfaction is low because of lack of "balanced" steam distribution. After the valve is once installed the needed adjustments to secure correct balancing can be made without interruption to service.

Available in all styles and patterns. Can be furnished in lever and wheel handle, or lock and shield types and in angle, straightway, right-hand and left-hand patterns for each of these types. Can be furnished with special extension stem where the valve has to be installed behind a grille.—C. A. Dunham Co., 450 E. Ohio St., Chicago, Ill.

Addition to Heavy Coated Electrode Line

No. 1127—Recent addition to the line of "Murex" heavy coated electrodes for arc welding is designed for bridging gaps where fit-up between plates is poor and, in the smaller sizes, may be used on vertical and overhead work, or to make rapid, single pass welds on light gauge materials. In addition, it will produce clean, sound, single or multiple pass fillets, states the maker.

Physical properties of the deposited metal are said to range from 74,000 to 84,00 lb per sq in. tensile strength with 26 to 24 per cent ductility. Works equally well with either d-c or a-c and may be used with straight or reversed polarity.—Metal & Thermit Corp., 120 Broadway, New York, N. Y.

Control System for Stokers Announced

No. 1128—Coal is metered to the fire on a basis of both time and temperature by new "Pyrometric" control system just announced. The controls operate the stoker under thermostat control from the room being heated, and make the most of the stable fuel bed characteristic of a coal fire to keep the heating plant warm and conditioned for use between thermostat operations, says the maker, who states that in effect the boiler or furnace is used as a small reservoir of heat ready for quick delivery, with attendant advantages of immediate response to changes in room temperature, shorter heating operations, less wear and tear on the heating plant, and smoother, more efficient heating. The system also provides positive assurance that the coal burner will not continue operating if for any reason the fire becomes extinguished.

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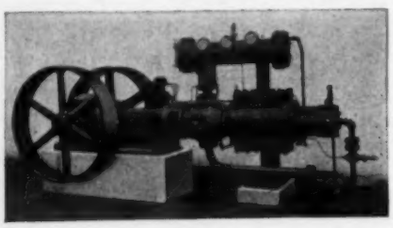
A unique feature is the indicator dial, which tells which one of four reasons is responsible for the operation or idleness of the burner.—Iron Fireman Mfg. Co., 3170 W. 106th St., Cleveland, Ohio.

Air and Gas Compressors Improved

No. 1129—Improved line of single horizontal three-stage compressors for pressures from 750 to 2,500 lb are particularly well suited for higher pressures, since the compression cylinder requires only one packing box, which is subjected solely to moderate pressures, says the maker. Leakage is thus reduced, a feature especially desirable when compressing valuable or inflammable gases. The compressor is applicable for high air pressure for any purpose, also for the compression of oxygen, hydrogen, helium and other special gases as well as refinery gas or straight natural gas. A choice of steam or motor drive is offered on all sizes.—Worthington Pump and Machinery Corp., Harrison, N. J.

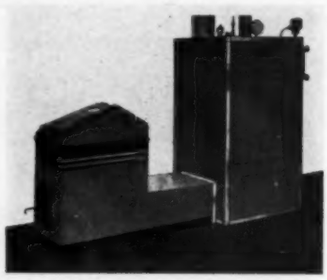


New Low Temperature Brazing Alloy Sizes

No. 1130—Interest in low temperature brazing, together with the variety of purposes for which silver brazing alloys are being used, have made it necessary to add new sizes and forms to the line of "Sil-Fos" and "Easy-Flo" alloys used for joining nonferrous metals. A new strip thickness, 0.005 in., has been added in widths of ¼ in. or more. To the wire forms, a new wire size 3/64 in. has been added and four new gauges of strip (0.020, 0.010, 0.005 and 0.003 in.—¼ or more in width).—Handy & Harman, 82 Fulton St., New York, N. Y.

Stoker-Burner Unit Announced

No. 1131—New stoker-burner unit, the joint product of two well-known manufacturers, is known as the "Fire Tender-Arco" unit, and is scientifically engineered for the automatic and efficient burning of lower-priced sizes of coal, state the makers. It is designed for business buildings and residences.



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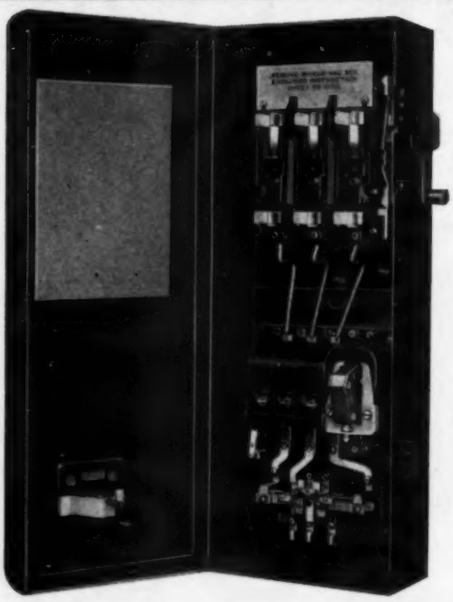
This Clark Bulletin 6018 is a combination Across - the - Line A. C. Starting Switch, fully enclosed and comprising a rugged three-pole magnetic contactor with thermal overload device and an approved externally operated disconnect switch which can be furnished fusible or unfusible. An external overload reset button is also provided.

Made in several standard sizes for various Horsepower ratings.



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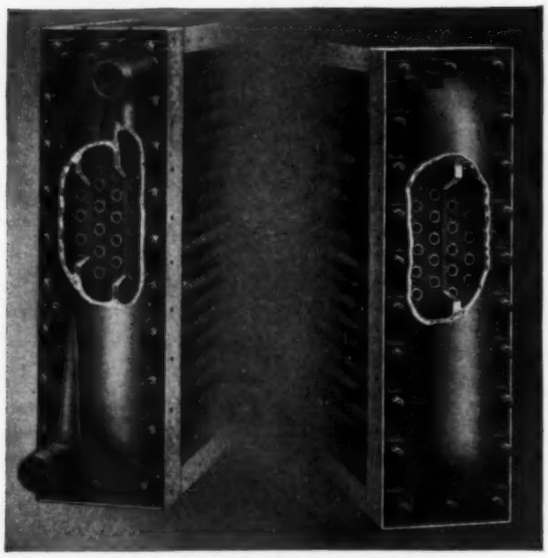
With Removable Headers Simplifies Cleaning of Tube Interior



LEFT: Water connection end of unit showing baffles for 18-tube single pass. For 36 tubes double pass, center baffles only used. RIGHT: Rear end for 18-tube single pass. For 36 tubes double pass, baffle omitted.

Aerofin Cleanable Tube units, for heating and cooling with water, have been designed for use where the prevalence of sediment or scale-forming chemicals in the water, makes periodic cleaning necessary.

Now, by the simple removal of a few bolts, both end headers may be disengaged, exposing the ends of all tubes.

Headers are designed so that water may be circulated in single or double passes (18 or 36 tubes in parallel) making possible the use of large quantities of water with small head loss. Send for descriptive folder.

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Keep Noise and Heat
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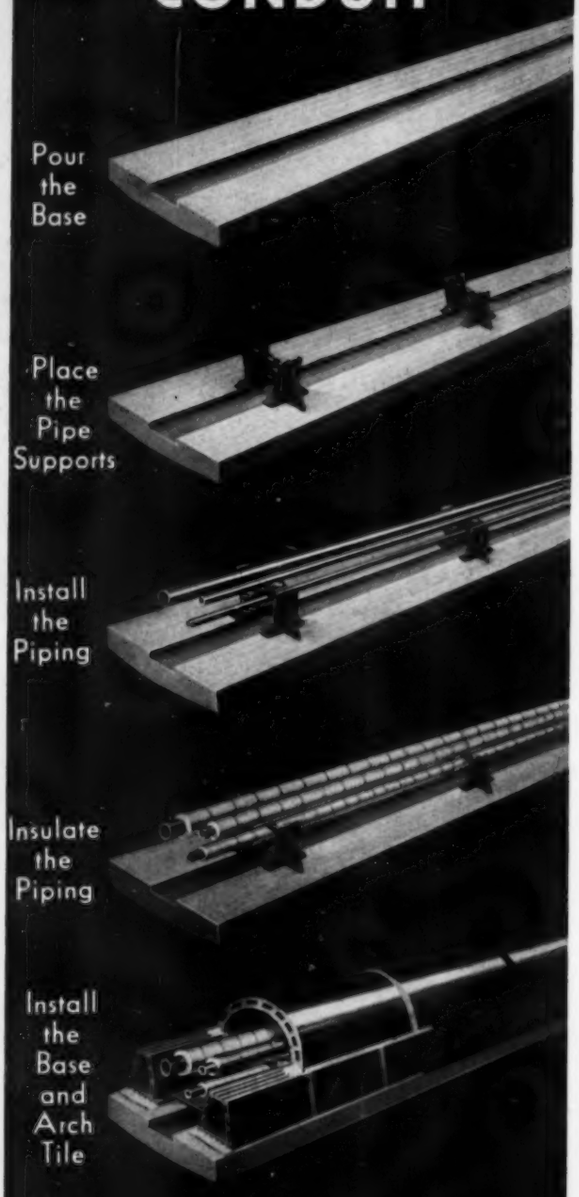
Fan, motor and blower noises cannot travel through air ducts lined with Ozite Hair Felt Duct Lining. This resilient material has a high coefficient of sound absorption at the frequencies at which most of such noises occur. It stops sound transmission and prevents vibration.

Heat losses are reduced to a minimum when ducts are insulated with Ozite Hair Felt Duct Insulation. This product with its high thermal conductivity of 0.246 B.t.u.'s is an effective barrier against cold.

Ozite Duct Lining and Ozite Duct Insulation are extremely easy to apply. They are flexible and can be quickly shaped to the contour of the air duct, fitting snugly around elbows and other parts usually difficult to insulate or line. Samples and specifications will be supplied on request. Write for them today!

AMERICAN HAIR & FELT COMPANY
Merchandise Mart Chicago, Illinois

THESE FIVE STEPS
show how easy it is to install steam mains underground in
THERM-O-TILE CONDUIT



Sold and Installed by Johns-Manville Construction Units in all Principal Cities.

H. W. PORTER & CO., INC.
825 FRELINGHUYSEN AVE., NEWARK, N. J.

out permitting heat to penetrate to the upper floors.—American Radiator Co., 40 W. 40th St., New York, N. Y., and Holcomb & Hoke Mfg. Co., 1545 Van Buren, Indianapolis, Ind.

New Stoker Fire Maintaining Timer

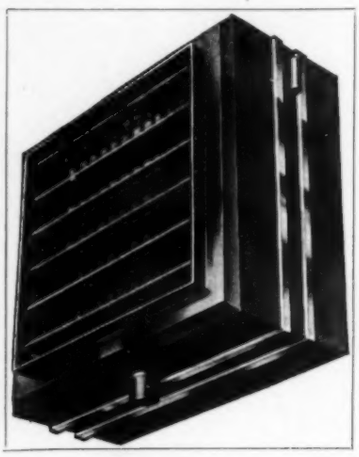
No. 1132*—"Stok-A-Timer" is a combination of the "Mercoid" transformer-relay and self-starting synchronous timer mechanism constructed into one unit, and is designed to maintain the stoker fire during periods when the thermostat does not call for heat, but has no provisions for out-fire control. Overheating and waste of fuel are prevented by a mechanical interlock in the timer control, which keeps the timer from operating the stoker immediately after the thermostat shuts off.

A feature is the fact that all electrical contacts are made by means of sealed mercury switches, which keep the contacting surfaces clean.

Timer is actuated by a positive self-starting synchronous motor movement, dials are graduated and adjustments made by hand without the use of tools, and no external transformer connections are required.—Mercoid Corp., 4201 Belmont Ave., Chicago, Ill.

Redesigned Unit Heater Line

No. 1133—A completely redesigned line of unit heaters, known as "Air-vector," has been announced. Exclusive features claimed are a new method of motor mounting, which is said to eliminate swinging or "pendulum action" of the unit, caused by motor vibration; the forming of two vertical ribs around the cabinet which increases strength of the assembly and deadens vibration of the cabinet panels; welded construction wherever practicable; and elimination of all except absolutely functional lines. The method of construction gives these heaters a modern appearance, and smooth finished surfaces are used entirely.



The units are made in a full range of capacities.—Airtherm Mfg. Co., 1474 S. Vandeventer, St. Louis, Mo.

Humidifier

No. 1134—Humidifier known as "Vigor-Air" is self-filling, automatically controlled, and evaporates up to 12 gal of water per day, according to the manufacturer. Made of cast iron, it weighs about 40 lb and is 22 in. long, 7 in. high and 8 in. wide. It is set on top of a radiator.

Inside of the humidifier is a fog chamber and a motor chamber. The motor has a double shaft, at one end of which is a fan that draws about 65 cfm of air through the machine into the fog chamber. At the other end of the shaft is a cylindrical brush, revolving at 3400 rpm, which creates a fog when in contact with the water, thus humidifying and cleansing the air, states the manufacturer—Vigor-Air Corp., 127 S. Fifth St., Philadelphia, Pa.

Portable Welder

No. 1135—Recently announced portable a-c welder ("Wonder Arc") is a special transformer type with a high power factor, having reactance control, static high frequency arc and sheet metal attachment that makes possible the welding of light weight metals. Capacities range from 125 to 600 amperes, 220 volts, 60 cycles, single phase.

No electrical connections between the power input and the welding leads. Can be used to weld on grounded systems, such as for thawing frozen water pipes. The exact amperage is supplied by a rotating knife switch control with amperage distinctly marked indicating each welding step, the maker points out.—Miller Electric Mfg. Co., 1134 W. Wisconsin Ave., Appleton, Wis.

Radiant Convector Introduced

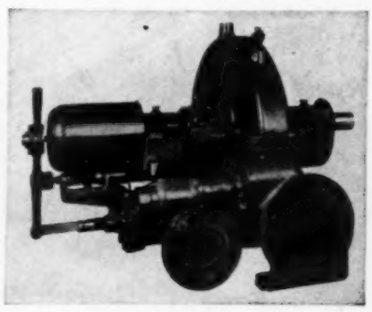
No. 1136—Providing radiant heat for the company's concealed radiation, new "Arco" radiant convector has been designed to retain at the same time all the advantages of the standard convector, including those of recessed or concealed radiators, space economy, accessibility for cleaning, and unobtrusive appearance.

A live radiant heat panel of cast iron replaces the front section of a regular fin type convector heating unit so that this panel can be fitted flush to a specially prepared opening in the enclosure. Construction of the rest of the unit and of the enclosure is standard and the cast iron panel offers a uniform flat surface in the front of the enclosure.

Vertical lines in harmony with section connections and the vertical openings of the convector enclosure are cast in the front of the radiant plate to give a uniform appearance. The plate is finished in a priming coat of grey and can be painted with the enclosure.—American Radiator Co., 40 W. 40th St., New York, N. Y.

Improved Steam Turbine for Mechanical Drives

No. 1137—For driving general purpose machinery in industrial plants and auxiliary equipment in generating stations and on shipboard, new and improved turbines have been announced. They are of the impulse type having one pressure and two velocity stages, and are built in capacities ranging approximately from 5 to 500 hp, at turbine speeds of 1000 to 5000 rpm. Suitable for use with steam pressures up to 650 lb ga and for total temperatures up to 750 F, they may be operated either condensing or non-condensing with rotation in either



SIMPLE
POSITIVE
LOW POWER CONSUMPTION

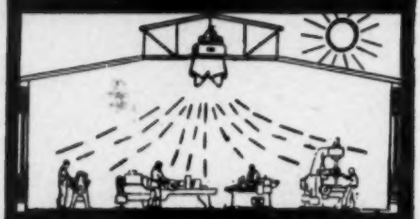
The popular trend toward A-P Controls is but a reflection of the super features that have made them supreme in the field.

Designed to insure against leakage past the valve. Simple and positive in operation against high pressures, and functions perfectly with very low power consumption.

Write for complete Bulletin of types, sizes and applications.

Consult AUTOMATIC PRODUCTS CO.

IT GIVES THE SAME UNIFORM DIFFUSIVE WARMTH AS THE SUN



Retain the same healthful, pleasant and uniform temperature as nature does in her warming process. A complete, broad penetration of heat over the entire working area of a plant — not spotty.

THE WING FEATHERWEIGHT HEATER
(Floodlights of Heat)

is well established — used in thousands of plants, yet it differs from all other heaters as floodlighting differs from spotlighting.

You owe it to yourself to have the real facts.

L. J. WING MFG. CO.
14th Street and 7th Ave.
NEW YORK, N. Y.

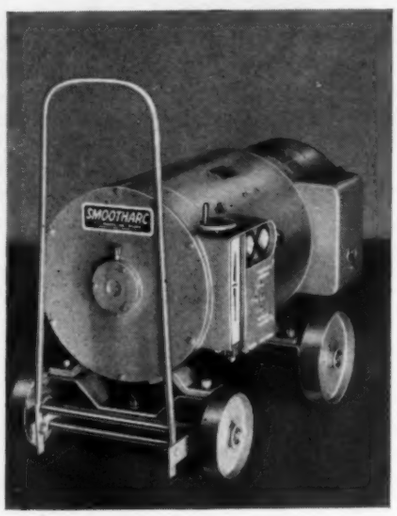
OTHER WING HEATING AND VENTILATING PRODUCTS

direction. Particularly adapted to driving pumps, forced and induced draft fans, compressors, Jordans, pulp beaters, pulverizers, line shafts, and similar apparatus, either direct connected or through gear or belt drive.

Applications include: Acting as reducing valves between boilers and various process pressure requirements, supplying steam and producing byproduct power at low cost in oil refineries, chemical plants, sugar mills, breweries, paper mills, and other industries. Also, in hotels, hospitals, schools, and offices, where the building, water heating, and related loads are high.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Welders Feature Simplified Design

No. 1138—New line of "Smootharc" welders features simplified design not only in outward appearance, but in operation as well with single current control, self-excitation and internal stabilization, the manufacturer states. Built in both vertical and horizontal types for stationary or portable mounting, the vertical units come in three sizes (75, 100 and 150 amperes) and the horizontal units in 200, 300, 400 and 600 ampere capacities.



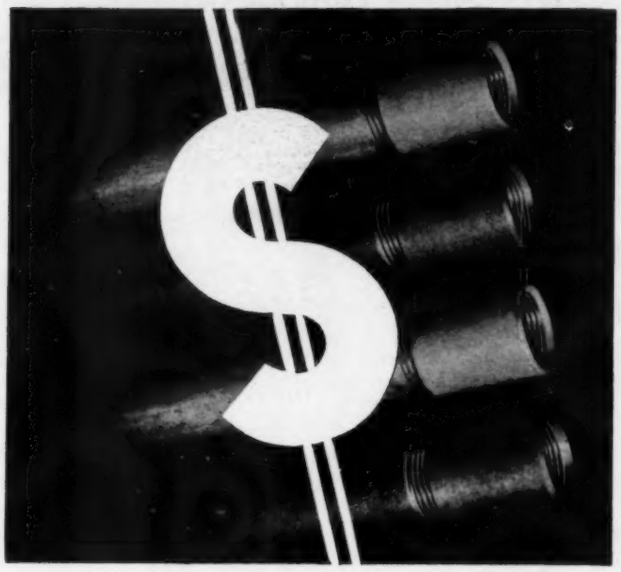
All are provided with single current control, made possible by patented design of shifting generator brushes. Self-excitation is accomplished through a set of auxiliary brushes placed ahead of the main brushes and connected to an auxiliary shunt winding. Through the use of interpole winding extended to the main pole shoes in such a manner that it serves the dual function of interpole winding, the welders are internally stabilized.—Harnischfeger Corp., 4400 W. National Ave., Milwaukee, Wis.

New Combination Trap

No. 1139—New combination thermostatic and inverted bucket blast "Super-Silvertop" trap has the advantage over ordinary traps in that it will remove entrained air when pressures drop to a few ounces or fraction of an ounce, according to the manufacturer. This is accomplished by bypassing the air around a water seal. Entrained air causes a bellows to contract, which opens the bypass and the air passes directly to the return line without going through the water.

These traps are available with pipe connections up to 1¼ in., and capacities up to 10,200 lb of water per hr at 15 lb pressure, according to the maker. Valves and seats are made of "Anderloy." It is stated that expensive maintenance caused by replacing floats is eliminated by the method of construction used,

A MATTER OF



and sense

To obtain contracts these days, it takes close figuring on bids. Here's how Fretz-Moon Pipe can help you install quality work at a profit. • Fretz-Moon Pipe is absolutely uniform. Every length is true to size, perfectly round, straight, accurately and cleanly threaded, tightly welded, and clean inside and outside. It bends, cuts and threads easily—the exclusive "continuous process" by which Fretz-Moon Pipe is made insures against hard or burnt spots in the metal—protects the original high ductility of the steel. It is available in extra long lengths without cross-weld. In galvanized finish, it affords a rust-resisting zinc alloy surface that will not crack or scale under severe bending. • And with all these features that make fitting easier and faster, and cut installation time to a minimum, Fretz-Moon Pipe costs no more than ordinary pipe. Use it for your next piping job and note the difference.

FRETZ-MOON TUBE CO., INC.
BUTLER • PENNA.

FRETZ-MOON PIPE
BLACK AND GALVANIZED

AS ONE'S WARDROBE
Meets Any
TEMPERATURE CHANGE

So Dunham Differential Heating
meets the Temperature Changes of
. . . . . Heating Weather

because it makes the Heat Supply continuously balance the Heat Demand. This ability of Sub-atmospheric Steam is far beyond that of ordinary systems that must have pressure, however slight, to effect circulation.

Differential Heating not only meets sub-zero weather with required temperatures of steam-under-pressure, but automatically circulates equally well, steam at any of the bland temperatures of the Steam Table down to 133 degrees.

Radiator heat output may be further reduced by automatically-accomplished partial radiator filling. Such an acute adaptability to varying heat requirements naturally eliminates wasteful overheating.

Differential Heating reflects its values in health and efficiency to those within its influence. In addition it offers a reduced heating budget beyond the ability of an uncontrolled system.

"If the Steam Table is Right DUNHAM Differential HEATING 'Differential' is Right"

C. A. DUNHAM COMPANY
450 EAST OHIO STREET • CHICAGO, ILLINOIS

ANOTHER NATIONAL FIRM HAS BECOME AN

Auditorium Licensee

The Roll

American Blower Corporation, Detroit, Mich.

Carrier Corporation, Newark, N. J.

Frick Company, Waynesboro, Pa.

General Electric Company, Schenectady, N. Y.

J. O. Ross Engineering Corp., New York, N. Y.

The Cooling & Air Conditioning Corp., (Division of B. F. Sturtevant Company) Hyde Park, Boston, Mass.

York Ice Machinery Corp., York, Pa.

Announcing that the **FRICK COMPANY** WAYNESBORO, PENNSYLVANIA,

has become a Licensee of this Corporation with the right to install Central Station Air Conditioning Systems or to grant permission to others to do so. By becoming a Licensee it has recognized the validity of all of the Auditorium Patents and may utilize all or any of the inventions therein.

All of the Licensees named may install Licensed Systems, or extend permission to others to do so. They have branch offices in many cities where a bound volume of Auditorium Patents is available for reference.

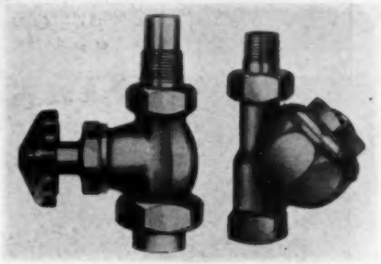
AUDITORIUM CONDITIONING CORPORATION

New York Office—17 East 42nd Street New York

because the open inverted bucket is not affected by pressure.—The V. D. Anderson Co., 1949 W. 96th St., Cleveland, O.

Packless Radiator Valves and Thermostatic Traps

No. 1140—Vertical packless radiator valves and thermostatic traps especially designed for concealed or cabinet type radiators have recently been developed. The double union packless radiator globe valve may be used on steam, vapor or hot water systems, and embodies the patented all metal packless construction standard with the manufacturer. The double union feature allows for simple installation, and the extended tail piece is a special feature for bottom connected radiators, extending into the radiator and preventing the accumulation and return of condensation through the supply valve.



Close roughing-in dimensions and simplicity feature the vertical trap, according to the manufacturer. Design of the body allows drainage of condensation, and the trap, therefore, is non-freezing. Cap is removable without disconnecting body from piping.—Jas. P. Marsh Corp., 2073 Southport Ave., Chicago, Ill.

New Line of Unit Heaters

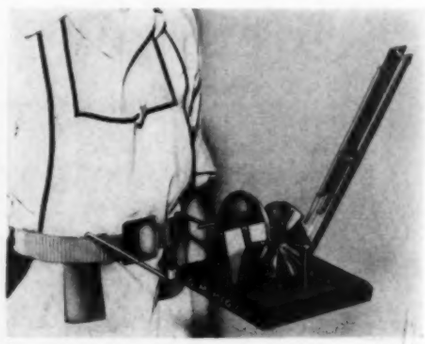
No. 1141—New line of "Rocop" unit heaters are of seamless copper tube construction with no soldered steam joints. The units have been designed for space heating requirements of churches, auditoriums, offices, factories, garages, laundries, milk stations, etc. The design is such as to eliminate expansion strains and at the same time to provide a unit which has short tube length and is of sturdy construction, according to the maker.

Unit No. 2188 is rated at 440 sq ft E. D. R., 1450 cfm of heated air, 5 lb. steam. No. 2186 is rated at 200 sq ft E. D. R., 783 cfm of heated air, 15 lb steam. No. 1414, medium pressure type, is rated at 190 sq ft E. D. R., 556 cfm of heated air, 5 lb steam.—Rome-Turney Radiator Co., E. Whitesboro St., Rome, N. Y.

New Sling and Hand Fan Psychrometers

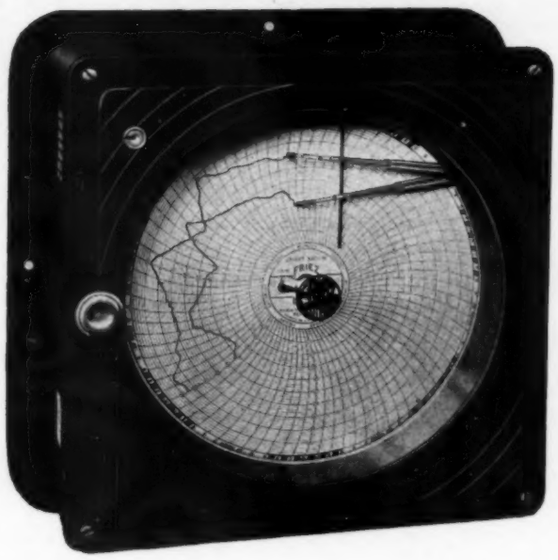
No. 1142**—Two new psychrometers have recently been developed, one a sling type and the other a fan type. One of the illustrations shows the fan type instrument ready for operation. It enables the technician to obtain correct relative humidity determinations by taking observations after walking to any section of the plant. It can also be used to determine if humidity conditions are uniform by simply walking around and noting whether or not there is any change in the thermometer readings. Its weight is about 3½ lb with all accessories.

All metal parts of the sling psychrometer are monel, and the thermometers are 9½ in. long and can be supplied with a range of either —20 to +120 F in 1 deg graduations, or 0 to 100 F in 0.5 deg markings.



Also illustrated is another model sling psychrometer in which the swivel handle folds over be-

Gentlemen, Your Witness



- Every large Air conditioning installation is worthy of a witness of its performance.
- That witness should be an eye-witness, able to report directly, without computations or deductions.
  - The Friez Air Conditions Recorder is just such an eye-witness. It reports directly temperature and humidity in per cent relative humidity—and from any remote location. You do not need psychrometric tables or further figuring after you have read the chart. It knows and gives all the answers. In fact it is the only such eye-witness in the field of air conditions instruments.
- Such an accurate and reliable eye-witness returns the value of its fee many times in time-conserved and in efficient product control.

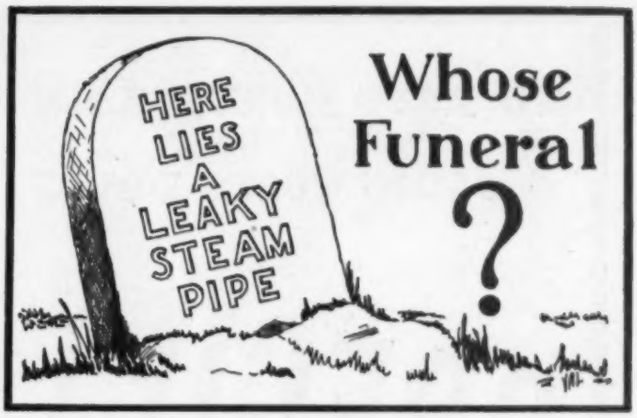
Write for Bulletin

Julien P. Friez & Sons, Inc.

"The Makers of America's Weather Instruments"

Subsidiary of
Bendix Aviation Corporation

BALTIMORE, MARYLAND

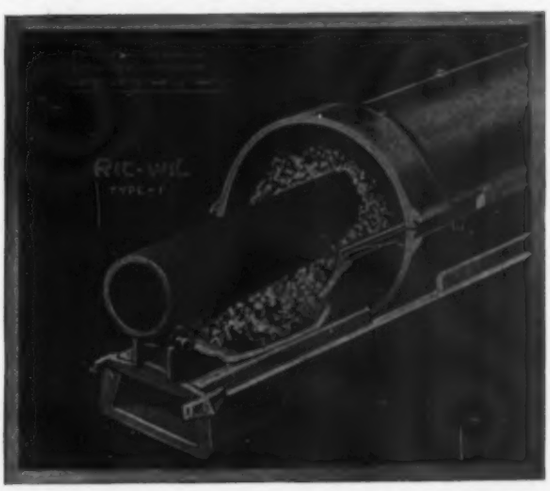


BURIED alive—that's *steam in underground lines.* Out of sight, out of mind—but it's *live* steam and it's always struggling to get out. If it does get out, whose funeral is it? Yours! Steam loss is recognized as one of the major items in power plant operating and heating costs. It must be faced, not forgotten.

The best method of facing and defeating it, as far as underground transmission is concerned, is protection with Ric-wiL Conduit. Ric-wiL Systems are correctly engineered, insulated and drained—to keep steam lines over 90% efficient. Different types in either tile or cast iron to meet all conceivable conditions. Choice of insulations, including the famous Ric-wiL Watertight Asbestos Dry-paC. Complete Ric-wiL service is available from coast to coast—engineering, installation, field supervision. Write for complete catalog, with Dry-paC sample for testing.

The Ric-wiL Co., Union Trust Bldg., Cleveland, Ohio
New York San Francisco Chicago
Agents in principal cities

Prominent engineering authorities claim: "A permanently dry trench is more than half of any underground job—for efficiency."



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RIC-WIL

CONDUIT SYSTEMS FOR UNDERGROUND STEAM PIPES

TO KEEP HEATING OR COOLING COSTS DOWN

SPECIFY CELOTEX

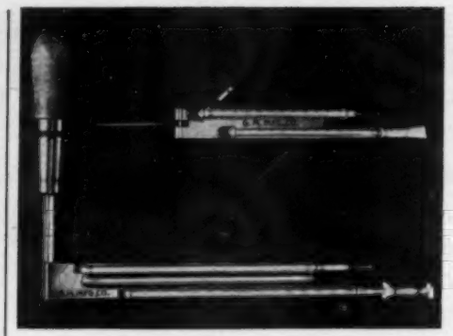
TIME after time, you'll find Celotex an *ideal* solution for your insulating problems. This insulating cane board has a thermal conductivity of only 0.33 Btu. per inch thickness. It is light, but strong. And it is *easily* cut and fitted with ordinary tools, right on the job.

The new Celotex Vaporseal Insulating Sheathing offers special advantages. Standard Celotex, integrally waterproofed in manufacture, is then additionally sealed *without loss of insulating efficiency* by a continuous coating of special asphalt. Furthermore, one side is coated with a bright metallic compound as an extra vapor seal.

Celotex Vaporseal Insulating Sheathing, as well as regular Celotex, is protected against Dry Rot and Termites by the patented Ferox Process. May we send complete information, and suggestions on special insulating problems?

THE CELOTEX CORPORATION
919 N. Michigan Avenue - Chicago, Ill.

CELOTEX
BRAND
INSULATING CANE BOARD
REG. U. S. PAT. OFF.



tween the thermometers when not in use. These thermometers are 5½ in. long and are calibrated for the range 0 to 100 F.—G. M. Mfg. Co., P. O. Box 151, Madison Square Station, New York, N. Y.

New Auditorium Patent Licensees

Frick Co., Waynesboro, Pa., manufacturer of refrigerating, ice making and air conditioning equipment, has signed a license agreement with Auditorium Conditioning Corp., New York, N. Y., it has been announced. It has the same privileges as all other licensees and may install air conditioning systems of the central station type utilizing the Auditorium patents or give permission to others to do so.

Buffalo Forge Co., Buffalo, N. Y., fan, washer and air conditioning equipment manufacturer has taken a license under all of the patents of Auditorium Conditioning Corp. It now may sell and install central station air conditioning systems or give permission to others to do so under these patents. In addition it may also manufacture and sell air conditioning units utilizing the patented features of these same inventions.

A. C. Guards Drug Products

Air conditioning of two large storage rooms at the Upjohn Co., Kalamazoo, Mich., insures the preservation of some 66,000 lb of drug products. The installation is designed to maintain an even temperature of 48 F in one room, 67 by 60 ft, and 44 F in a smaller one, 43 by 22 ft. Relative humidity is held at approximately 85 per cent to prevent any drying out of the barrels used to store drug products.

Refrigeration is provided by a 15 hp compressor attached to two cooling units, one of 8½ tons in the larger room and the other of 4½ tons in the smaller one. Air is diffused throughout the rooms by means of fans in the cooling units.

Warning signal lights on a control panel notify the operator or watchman if any part of the equipment should cease to function, while the solenoids that automatically shut off the system when the proper temperature is reached are by-passed so that the whole system may be operated manually at any time desired.

Photo courtesy Kelvinator Corp.

Air conditioned storage room for drug products at the Upjohn Co., Kalamazoo, Mich., with cooling equipment in background

Burning the Heavier Oils

By Glenn Arnold*

WHILE some laymen still speak of industrial or heavy oil burning equipment as "crude oil burners," there is nothing crude about any of the oil we use today as fuel, nor is there anything crude about most of the burners. Fuel oils are classified in grades from No. 1 to No. 6. I will limit my remarks to the application of equipment burning the heavier oils, Nos. 5 and 6, automatically in low pressure heating plants. As engineers and architects you are naturally interested in when and why to specify equipment for automatic use of the heavier oils. The primary consideration, of course, is economy of operation and dependability.

In this locality, No. 2 oil, for which many automatic burners are available, sells for about 6¼c per gal of 138,500 Btu, or 4.5c per 100,000 Btu; No. 5 oil for 4.405c per gal of 148,000 Btu, or 3c per 100,000 Btu; and No. 6 oil for 3.5c per gal of 152,000 Btu or 2⅓c per 100,000 Btu. Of course, the real measure of cost is the cost for Btu's. As No. 6 oil seems to be much cheaper than the others, why not use it exclusively?

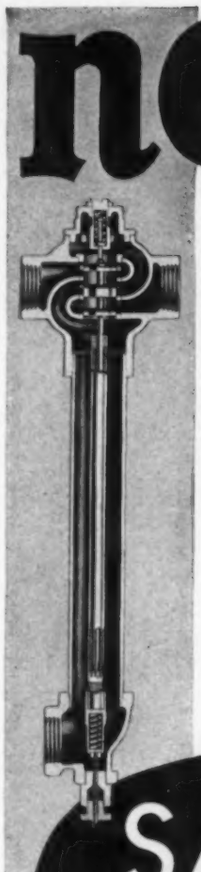
The use of No. 6 or Bunker C oil is not the answer to economy in *all* cases. Automatic equipment burning heavy oil is not a cure-all. I do not believe No. 5 oil should be used in any plant which requires less than 8 to 10 gal per hr, and I do not believe No. 6 oil should be used in a heating plant requiring less than 15 gal per hr, or approximately 22,000 to 25,000 gal per season. By that I do not mean to suggest that every heating plant with a load of 5,000 sq ft of steam radiation should be burning No. 6 oil.

From a practical standpoint, the cost of equipment and oil storage must be given consideration, and from an engineering standpoint the combustion space, type of boiler and draft conditions are important. No. 2 oil can be purchased in lots of 100 gal or more, with delivery as often as necessary. No. 5 oil is delivered in compartment or full tank lots, usually 1,500 gal at a time, so a 2,000 gal tank or larger is required. No. 6 oil is delivered hot in full tank wagon loads through a 5 in. pipe and at least a 2,500 gal tank should be available with manhole and ladder for cleaning the tank from time to time.

Automatic equipment and a 275 gal storage tank can be bought for almost any price. Automatic equipment for No. 5 oil, with suitable storage tank costs approximately $1,300 for the smallest size. Automatic equipment for No. 6 with suitable storage tank costs approximately $1,800 for the smallest practical size. Thus, even if 2¼c a gal on 5,000 gal of oil per year, was saved by using the heavy oil, the difference in capital investment would offset the saving.

Bunker fuel oil is the residuum of a complete refining process, and naturally it is very much heavier than the original crude. Since it has been subjected to high pressures and temperatures in the refining process, the carbon content is in some measure affected—solidified or coked. When heat is again applied, this carbon content is felt in the clogging of strainers, heaters, burners and control mechanism. Its most important characteristic is

*Petroleum Heat & Power Co., Boston, Mass. Abstracted from an address before a joint meeting of the Boston oil burner association, air conditioning bureau, and the Boston chapter of the *American Institute of Architects.*



new!

Here is an automatic mixing valve for hot and cold water that meets all the requirements of industry.

Wherever water is required at different temperatures—for showers, wash rooms, cleaning, or process work—this simple, compact and self-contained unit will do the job of mixing automatically, without supervision.

SARCO Water Blender

has the following valuable features:

1. Can be furnished for any temperature between 30° and 250° F.
2. Adjustable in the field a total of 50° F.
3. The valve has double seats for both hot and cold water. It is, therefore, fully balanced. Differing or fluctuating pressures will not disturb the operation. No reducing valves are required.
4. Furnished in all brass construction for installations where appearance is important—nickel or chromium plated if desired. Also made in iron body with bronze trim.
5. Available in sizes ¾" to 4" for pressures up to 150 lbs.

The Sarco Blender is used also as an automatic by-pass valve for the control of temperatures of cooling water or brine in connection with unit coolers, brine coils, engine jackets and similar applications.

For full information write for Bulletin O-140.

SARCO COMPANY, Inc.

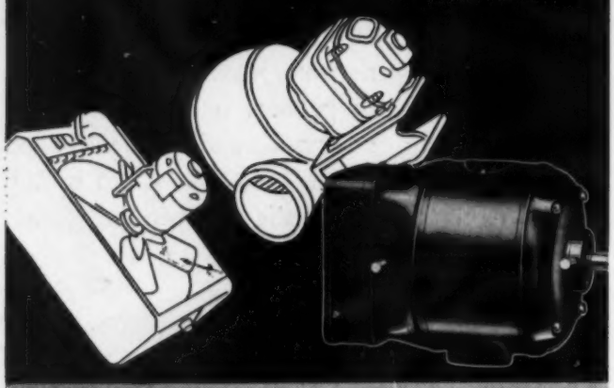
183 Madison Ave. New York, N. Y.

Branches in Principal Cities

Sarco Canada Limited, Federal Bldg., Toronto, Ont., Canada

BALDOR BUILDS *Better Motors*

NEWS! about BALDOR MOTORS



New FLUSH TYPE WALL CONTROLLER
for Variable Speed Condenser Motors

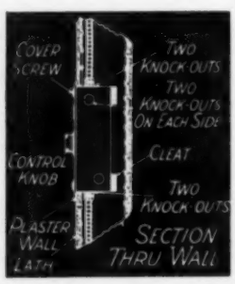
ANOTHER *Exclusive* BALDOR FEATURE

Handsome brushed brass or black crackle finish. Cover size, 7x9¾ in. 3 in. deep.

More Efficient·· Neater Appearance·· Easier Serviced

4-speed Baldor Controller. Fits neatly into wall—as flush as a wall switch. Control mechanism assembled on a separate frame—easily installed or removed.

LISTED AS STANDARD BY THE UNDERWRITERS



Easily fitted into wall, fastens as any junction box. Knockouts on 4 sides. Easily wired—only 2 wires required.

Makes Your Product Easier to Sell

Recommended for installations where controller is conspicuously placed, as in offices, halls and lobbies where neatness and harmony are requisite.

Write for BULLETIN FT 36

BALDOR ELECTRIC COMPANY
4338 DUNCAN AVE. — ST. LOUIS, MO.
Sales and Service Offices in Principal Cities

BALDOR
A BETTER MOTOR

its viscosity. Where viscosity uniformly decreases with temperature rise, little difficulty is encountered. When it diminishes rapidly, with only a small temperature change, difficulty is encountered in designing proper compensating devices to insure constant oil flow to the burners. While No. 6 oil viscosity is described at from 100 to 300 seconds at 122 F, much No. 6 is delivered at lower viscosity. I have found some as low as 23 sec.

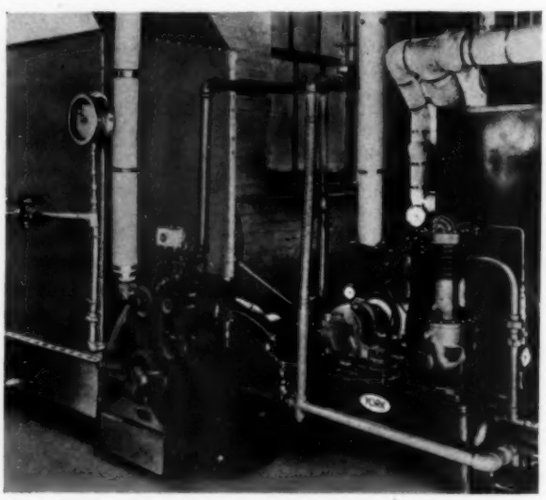
Before installing equipment to burn No. 6 oil automatically we must determine the type of boiler to be fired, location of storage, current available, and whether the boiler foundations are waterproofed. It is advisable to furnish adequate combustion volume so that the heat release does not harm the furnace refractory, so it is often necessary to excavate under the boiler to form a pit, or to raise the boiler. The best of refractory material should be used, and placed with the best workmanship, as usually the highest point of maintenance is the furnace.

Air Conditioning System Operated by Gas Engine

To test the feasibility of operating an air conditioning system with natural gas power and to develop the operating costs of such a system, the Atlanta Gas Light Co. last summer installed an air conditioning system operated by a gas engine for the president's office, two other private offices, and a reception room.

Several of the gas utilities have instituted experimental studies on the possibilities of air conditioning systems using gas energy. They look to air conditioning as means of increasing their load, not only for heating in the winter, but also for cooling and dehumidifying in the summer. The cooling period usually comes in an off-peak period, which makes the idea doubly attractive.

The system includes a "Freon 12" condensing unit, complete as usually furnished but without motor, a unit air conditioner with decorative casing, a forced draft cooling tower, and a condenser water pump. The cool-



Automatic gas engine driving compressor for air conditioning offices

Marquette Building, Chicago, Ill.

REDUCE HEATING COST $6,931.92 IN TWO YEARS

16-Story Chicago Building Uses Webster Moderator System to Slash Steam Consumption

CUTS COST OF INSTALLATION

Chicago, Ill.—The cost of heating Chicago's 16-story Marquette Building was reduced $6,931.92 in two heating seasons as a result of application of a Webster one-pipe Moderator System in the fall of 1934.

The Webster Moderator System was originally designed for two-pipe steam heating systems, but by incorporating certain modifications in the control it was possible to avoid the cost of installing separate return piping and at the same time produce results reasonably comparable with those obtained by controlled two-pipe systems.

During 1934-35, steam consumption was reduced 3,139,000 lbs., the equivalent of $2,594.29. Steam savings for 1935-36 were 4,846,000 lbs., a cash reduction of $4,337.63.

In addition to reducing heating costs, the Webster Moderator System regulates steam circulation in the Marquette Building so that the entire building heats evenly and rapidly. The Marquette Building has 46,930 sq. ft. of installed direct radiation. William Lees, Inc., of Chicago, acted as modernization heating contractors.

The method of computing the steam savings was developed by Mr. Earl Shultz, Vice-President of the Illinois Maintenance Company and agent of the Marquette Building. Mr. Shultz' method of measuring the savings served as a basis for an article, "Determination of Heat Saving" in SKYSCRAPER MANAGEMENT, a leading building management publication. A few reprints of this article are available for interested building owners and managers.

PROOF that *One-Pipe* installations can be *orificed* and effectively controlled with the Webster Moderator System is afforded by the operating record of the Marquette Building.

A Webster Heating Modernization Program offers building owners and managers an opportunity to protect their property investment, keep tenants well satisfied and make a substantial reduction in heating expense.

Webster Systems have been installed in 70,000 buildings — new buildings as well as old.

If you are interested in heating *new* buildings, or in improved heating service and lower heating cost in your present building, address

Warren Webster & Company . . . Camden, N. J.
Pioneers of the Vacuum System of Steam Heating
Branches in 60 principal U. S. Cities . . . Darling Bros., Ltd., Montreal, Canada

PHOS-COPPER Saved $10,000 IN SIX MONTHS

No special skill is required to braze with Phos-Copper as this picture testifies. The young lady is brazing a refrigerator dehydrator tank.

WESTINGHOUSE 1886 GOLDEN JUBILEE 1936

It's hard to believe a brazing alloy could mean such savings, but it's true.

After two years of extensive tests, a well-known electrical refrigerator manufacturer standardized on Phos-Copper in preference to all other brazing alloys.

The result was a $10,000 saving in six months . . . a saving made possible by lower first cost . . . by the superiority of joints which meant fewer rejections . . . and because less labor was required in the use of Phos-Copper.

Try Phos-Copper. Then compare costs with any other brazing alloy. You, too, may find worthwhile savings by standardizing on Phos-Copper—the *superior* brazing alloy.

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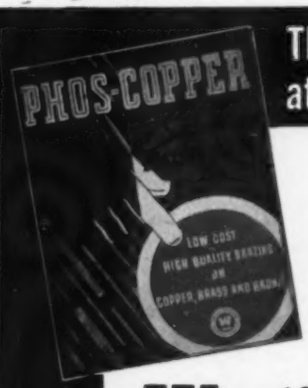
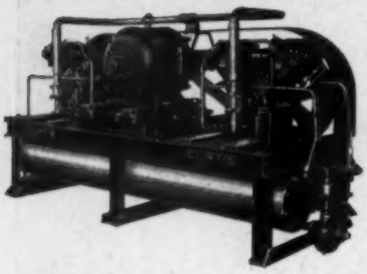


TRY PHOS-COPPER at our expense

WRITE FOR A TRIAL SAMPLE. We will also send you, without obligation, a copy of Booklet 2076 which contains technical and test data on Phos-Copper. Address Dept. 5-N, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Westinghouse

DEPENDABLE PERFORMANCE
LESS SERVICE



=MORE PROFIT

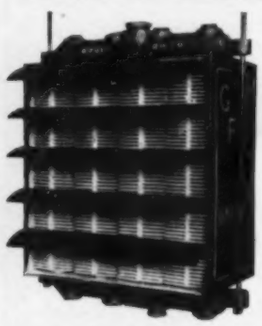
● No matter what the manufacturer's guarantee, there is no profit in service calls. Furthermore, necessity for service calls makes dissatisfied customers.

The solution is dependable performance—the kind you get from the condensing units made by Curtis. Year in and year out, Curtis units perform quietly, economically, efficiently. You'll have satisfied users, if you specify Curtis equipment, and that means more profit. The Curtis name and the Curtis product have been dependable since 1854.

CURTIS

CURTIS REFRIGERATING MACHINE COMPANY
Division of Curtis Manufacturing Co.
1960 Kienlen Ave., St. Louis, U. S. A.

"WE HAVE NEVER HAD ANY LEAKS OR REPAIRS ON –



GRID UNIT HEATERS

And we have sold many of these units under a guarantee. In no case have we had any trouble. That is why we feel they are one of the best unit heaters made, if not the best" (Name of heating contractor on request.)

GRID Unit Heaters do not require repairs and are free from leaks and breakdowns, because the heating sections are all cast aluminum. No electrolysis can be developed in a GRID Unit Heater. They are made to last indefinitely. Let us send you complete details.

THE UNIT HEATER & COOLER CO.
WAUSAU, WISCONSIN
Offices in all principal cities

GRID UNIT HEATER

ing water serves both the condensing and the gas engine.

The compressor is driven by an automatic gas engine operating on gas supplied by the Company. Speed of the engine, 1000 rpm, is reduced by suitable pulley sizes to drive the compressor at approximately its standard speed.

A separate belt from the engine drives the fan of the forced draft cooling tower, and the condensing water pump which was installed on the compressor base in place of the usual electric motor.

Operation of the system is automatic. A high and low temperature thermostat, and a humidistat, control the starting and stopping of the gas engine by means of a six volt control circuit. This circuit takes its energy from the engine's storage battery.

The installation was placed in service on July 3, and a meter reading taken on October 5 showed a consumption of 55,000 cu ft of natural gas, according to E. P. Kramer, industrial engineer of the Atlanta Gas Light Co., in charge of the installation.

Mr. Kramer estimates that the compressor engine was operated 430 hr during this period. This figure is higher than normal, he believes because the system was operated longer than regular office hours, and also because some employees from non-conditioned areas used these offices during the extremely hot weather of last summer.

The only parts of the system which required attention during the summer were the storage battery and the lubricating system on the gas engine. The generator has been set at a sufficiently low charging rate to maintain a constant charge and eliminate the need for adding water to the battery.

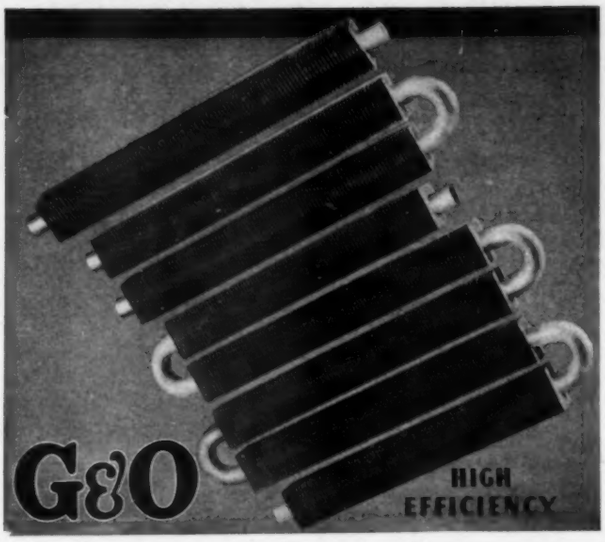
Mr. Kramer says he is planning to provide an extra two quarts of lubricating oil in the automatic feeder on the engine, so next season the air conditioning system will operate without any attention whatsoever.

To attain quiet operation, a small amount of isolation was placed between the engine base and the slide rail, and an insulating wall and ceiling installed. The compressor itself was not isolated. The equipment is installed on the basement sales floor, but no operating sounds are noticeable in the sales areas, it is said.

AIR CONDITIONING REVIEW

Data for Heating, Piping and Air Conditioning's annual review of air conditioning installations are now being assembled. This survey, to appear next month, will show the number and capacity of air conditioning installations of various types made during 1936 compared with last year, and the totals to date. Other pertinent figures and comparisons will be included.

Questionnaire blanks have been mailed to many public utility companies and to other sources of such information. However, the editors will greatly appreciate the help of any who have not received these blanks and who have available such figures for any city or area in the United States. If you did not receive a blank, please send the information in whatever form it is available to Heating, Piping and Air Conditioning, 6 North Michigan Ave., Chicago, Ill.



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If this Housing ever Breaks or Distorts we will replace it Free
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That guarantee tells the whole story of the amazing strength of RIDGID Pipe Wrenches. It explains why RIDGIDs cut your wrench repairs fully 75%.

Chrome molybdenum nickel alloy jaws — yes, and alloy handles also. Pass U. S. Government and Navy tests—yes. We say RIDGID Wrenches are ALL HEAVY-DUTY—and say it with a plain guarantee.

You'll like also the no-lock jaws, heel jaw replaceable, hook jaw with handy pipe scale on it; adjusting nut that spins easily in all sizes, 6" to 60", and other features.

See it at your Jobber's.

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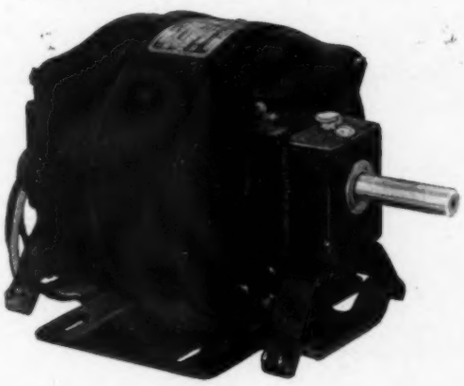
HOLTZER-CABOT MOTORS



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UNIT HEATERS
UNIT VENTILATORS
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AIR CONDITIONING UNITS

Our engineers will gladly confer with you. Their experience will be helpful. Write Dept. 20 for bulletin.

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FLOATING HEATING ELEMENT

All copper heating element. Headers of round seamless copper tubing. Core tubes orificed for even steam distribution. Tubes hydraulically expanded into copper fins. Entire heating element floats in housing. McQUAY patented construction.

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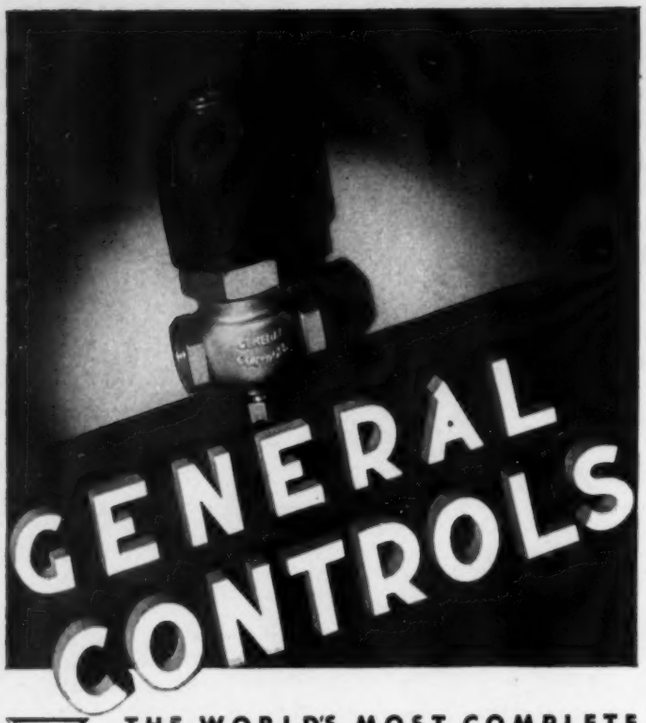

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Get the facts—mail this coupon with your business letterhead.

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Conventions and Expositions

Twelfth National Exposition of Power and Mechanical Engineering: November 30-December 5, Grand Central Palace, New York, N. Y. Manager, Charles F. Roth, Grand Central Palace, New York, N. Y.

American Society of Mechanical Engineers: Annual meeting, November 30-December 5, New York, N. Y. Secretary, C. E. Davies, 29 W. 39th St., New York, N. Y.

American Society of Refrigerating Engineers: Annual meeting, December 2-4, New York, N. Y. Secretary, D. L. Fiske, 37 W. 39th St., New York, N. Y.

Welding Conference: 12th annual conference and exhibit on welding, December 10-11, Purdue University, Lafayette, Ind. J. D. Hoffman, Director, Department of Practical Mechanics, Purdue University.

National Warm Air Heating and Air Conditioning Association: Winter meeting, December 15-17, Stevens Hotel, Chicago, Ill. Managing Director, Allen W. Williams, 50 W. Broad St., Columbus, Ohio.

American Society of Heating and Ventilating Engineers: Annual meeting, January 25-27, Hotel Statler, St. Louis, Mo. Secretary, A. V. Hutchinson, 51 Madison Ave., New York, N. Y.

Oil Burner Institute: Oil burner and air conditioning exposition and convention, March 15-19, Commercial Museum, Philadelphia, Pa.

International Association for Testing Materials: 2nd International Congress, April 19-24, London, England. Honorary Secretary, K. Headlam-Morley, 28 Victoria St., London, S.W.1.

Short Course in Coal Utilization: May 25-27, University of Illinois, Urbana, Ill. D. R. Mitchell, Department of Mining and Metallurgical Engineering, 212 Transportation Bldg., Urbana, Ill.

Smoke Prevention Association: Annual convention, June 2-4, Hotel Pennsylvania, New York, N. Y. Secretary, Frank A. Chambers, 139 N. Clark St., Chicago, Ill.

American Society for Testing Materials: Annual meeting and exhibit of testing apparatus, June 28-July 2, The Waldorf-Astoria, New York, N. Y. Headquarters Office, 260 S. Broad St., Philadelphia, Pa.

Recent Trade Literature

For your convenience in obtaining copies of bulletins, see coupon on page 142.

No. 2194—ACCESSORIES: American Radiator Co., 40 W. 40th St., New York, N. Y. Looseleaf portfolio describing and illustrating complete line of "Ideal-Arco" accessories for heating systems, including air, vacuum, and vent valves; radiator valves; domestic water heaters; damper, tank, temperature and pressure regulators; specialties; gauges; and miscellaneous items.

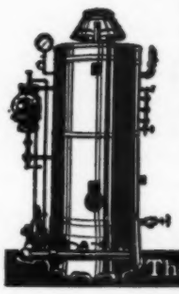
No. 2195—AIR CONDITIONING COILS: Fedders Mfg. Co., 57 Tonawanda St., Buffalo, N. Y. Issue of "Fedders News" (Vol. 3, No. 11) including an article on the effect of different variables on the cooling capacity of water type air conditioning coils. Information is given on the effect on heat transfer of inlet dry bulb temperature, inlet relative humidity and air velocity.

No. 2196—BEARINGS: Randall Graphite Products Corp., 609-613 W. Lake St., Chicago, Ill. 24 p. catalog of graphite bronze bearings, listing inside and outside diameters and lengths of standard bronze graphite bushings and sheave bearings; figures on inside diameter reductions for press fitted bearings are given.

No. 2197—BOILER FEEDWATER TREATMENT: Bloomfield Chemical Co., 169 Bloomfield Ave., Bloomfield, N. J. 4 p. folder on "Scale-Kem" treatment for boiler feedwater, discussing the subjects of water, scale, prevention of scale, and corrosion.

No. 2198—BOILER WATER CONDITIONING: Elgin Softener Corp., Elgin, Ill. 16 p. bulletin presenting a non-

That's all the time you need spend to run this BOILER for a 12 hour day



From 5 to 10 minutes a day is all the manual attention required when you install a KANE Gas Fired Steam Boiler. That's proven by data obtained from actual use in the field!

Automatically operated, the KANE supplies a CONSTANT pressure of clean steam at practically no labor cost—negligible maintenance cost—and comparably reasonable operating cost.

There's more dollar saving with the KANE than with any other boiler!

Why not investigate today? Certified performance records are yours, without obligation.

● *You'll want to know, too, about the Ofeldt Gas Fired Boiler and the M.K.O. Boiler Feed. Shall we send you that data at the same time?*

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Everything for Air Conditioning

Expertly engineered and ruggedly built propeller, blower and blast type unit heaters, air washers, propeller fans, blowers, blast coils, etc. There's every type and size of air conditioning equipment in the National Line with one nameplate and one guarantee. No matter what your requirements may be, they will be best filled with National equipment.

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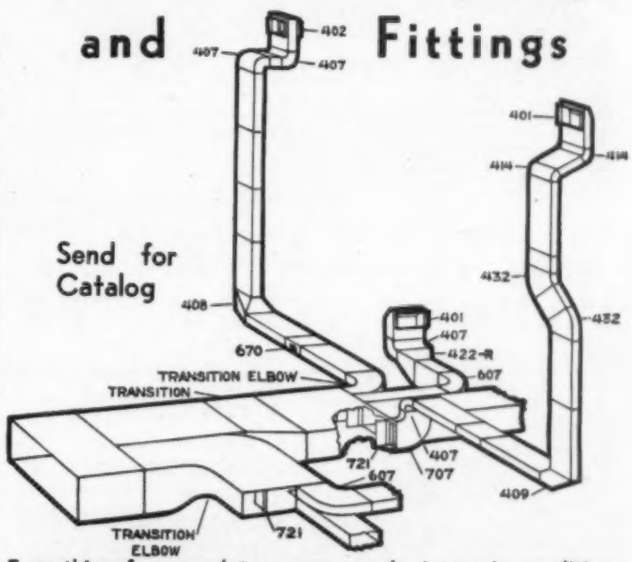

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technical discussion of methods of boiler water conditioning, showing the importance of selecting the right method to condition various waters, and emphasizing the importance of the subject if operation is to be efficient. Among the topics covered are how impurities accumulate, the dissolved impurities in boiler feedwater, and the four essentials of boiler water conditioning. This company's systems are briefly described and diagrammed.

No. 2199—CONTROL DEVICES: Alco Valve Co., Inc., 2628 Big Bend Blvd., St. Louis, Mo. Looseleaf catalog of automatic control devices for refrigeration and air conditioning, including thermo valves for various refrigerants, constant pressure expansion valves, float valves, float switches, magnetic stop valves, and liquid and suction line filters.

No. 2200—CONTROLLERS: The Foxboro Co., Foxboro, Mass. 28 p. bulletin on valves for air operated controllers, giving a comprehensive review of controlled valves of both the throttling and quick acting "open and shut" type. Modern controller accessories are described, a discussion of operating characteristics, specifications and dimensions of valves for throttling control are included, and basic data for computing valve sizes and range for various fluids and operating conditions are included.

No. 2201—DUST CONTROL: American Foundry Equipment Co., 555 Byrkit St., Mishawaka, Ind. 24 p. data book, one-half of which is devoted to description of the "American Dustube" dust collecter and its applications, and the last half of which is devoted to engineering data covering specifications for exhaust piping, care of dust control system, static pressure readings and how to take them, air volumes in pipe lines at various velocities, and a dust control analysis sheet.

No. 2202—ENCLOSURES: American Radiator Co., 40 W. 40th St., New York, N. Y. 4 p. circular describing and illustrating "Arco" enclosures for convector radiators in apartment houses.

No. 2203—FLUE PIPE: Johns-Manville, 22 E. 40th St., New York, N. Y. 20 p. booklet on "Transite" flue pipe, an asbestos-cement product for venting gas burning appliances. Besides describing the pipe, photographs of installations are shown, technical data given, and detail drawings presented.

No. 2204—GAS ENGINES: Waukesha Motor Co., Refrigeration Div., Waukesha, Wis. 4 p. folder on automatic gas engine power units, available in three models with available horsepowers at governed speed, using 1,000 Btu gas, of 21, 42 and 72. Designed for applications in apartments, hotels, office buildings, banks, stores, shops, theaters, hospitals and homes. Features carefully described, specifications and sizes given.

No. 2205—HYDRAULIC FORGING PRESSES: Chambersburg Engineering Co., Inc., Chambersburg, Pa. 12 p. bulletin illustrating and describing steam hydraulic high speed forging presses, including details and dimension tables.

No. 2206—INSTRUMENTS: Leeds & Northrup Co., 4952 Stenton Ave., Philadelphia, Pa. Broadside entitled "Power Plant Measuring Instruments, Telemeters, Automatic Controls," briefly describing instruments which indicate, record, signal and control, and describing their applications.

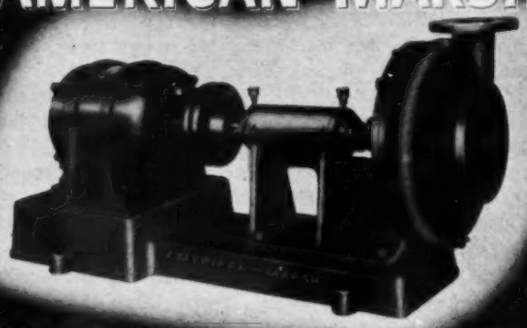
No. 2207—INSULATION: American Flange & Mfg. Co., Inc., 30 Rockefeller Plaza, New York, N. Y. 12 p. bulletin on "Ferro-Therm" metal insulation, with information on its use in refrigeration work.

No. 2208—LUBRICATION: The Texas Co., 135 E. 42nd St., New York, N. Y. Issue of "Lubrication" (Vol. 22, No. 10) including data on refrigeration and compressor lubrication. Among the subjects covered are selection of lubricants, types of lubricating systems, oil separator operators, sealing the stuffing box, and reclaiming compressor oils.

No. 2209—MOTORS: Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Leaflet describing improved design of explosion tested direct current motors. Available in a range of sizes from 5 to 75 hp, and 115, 230 and 550 volts.

No. 2210—OIL FIRED BOILERS: National Radiator Corp., 221 Central Ave., Johnstown, Pa. (a) 4 p. ready reference chart of "National" oil heating boilers, illustrating each type, and

AMERICAN-MARSH



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Heating men from coast to coast are discovering that Fedders Unit Heaters are built as good as they look! The performance you get out of them is the result of the engineering that goes into them. Write for Catalog 542 . . . it takes them apart for you.

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The most copied pump in America —

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Why? Because at the outset, Pomona engineers started on bedrock with a fundamentally correct design. They believed they were right—built pumps—and owners proved they were right. Owners talked about the dependability and economy of Pomona Pumps. The reputation spread—all over the world. New factories had to be built to handle orders. An announcement of the opening of a complete new eastern plant will be made next month.

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WHY BUY AN IMITATION?

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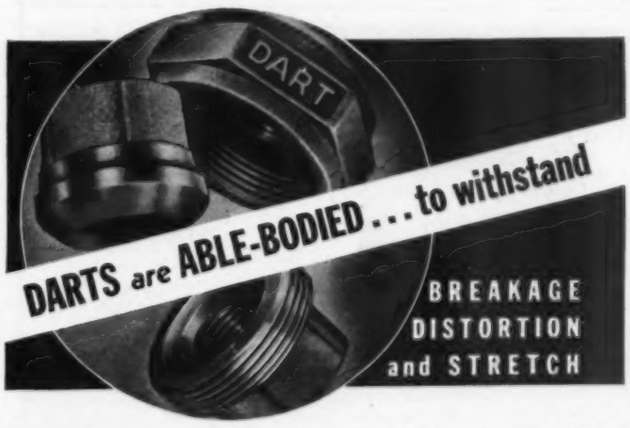
POMONA TURBINE PUMPS



Physical fitness for the strain of pipe union service requires a sound, rugged body. So Dart uses a special grade of iron that is especially suited to the purpose. Both pipe ends and nut are made from air-refined malleable of high tensile strength and yield point, with a lower percentage of elongation than steel. Practically unbreakable, Dart bodies also have exceptional resistance to thread-distortion.

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E. M. DART MFG. CO. PROVIDENCE, R. I

50 PATTERNS, OVER 1000 SIZES

If YOU'RE "fussy" about WRENCHES demand only WILLIAMS

SUPER-DUTY DROP-FORGED TOOLS

FOR THE LATEST DEVELOPMENT IN UNIT HEATERS

Write for Catalog H-12

This new catalog, just off the press, gives full details, including condensed capacity charts, on the new Airvector Unit Heater.

Airvector Unit Heaters have many exclusive points of design and construction, including ribbed "vibration-proofed" cabinets, unique "no-pendulum-action" method of motor mounting, distinctively designed cabinets, increased capacity, and a complete range of sizes for any job.

Write at once for Catalog H-12, and learn of the many improvements the Airvector provides in the unit heater field.

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The Engineered Line of Unit Heaters

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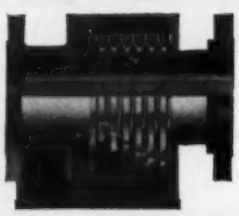

Fully guided, packless, steel body joint with protected expansion element for high pressures and high temperatures; requires no maintenance. Write for Bulletin No. 35-50 H.P.

See our Exhibit at New York Power Show, Nov. 30-Dec. 5th.

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NORTH TONAWANDA N.Y.
OVER FIFTY YEARS IN BUSINESS

AIR WASHING NOZZLES

ROTOJET Nozzles furnished in sizes from ¼" to 2½" pipe connections. Nozzle with cap removed shows involute whirl chamber. Binks ROTOJET Clog-Proof Spray Nozzles are the first choice of engineers everywhere for more efficient AIR WASHING. Send for Bulletin 50 today.

BINKS MANUFACTURING CO., 3106 Carroll Ave., Chicago
WINDSOR, ONTARIO, CANADA

giving ratings and general data. (b) 10 p. general catalog on "National Toridheet" cast iron oil heating unit, giving complete information.

No. 2211—PIPE TOOLS: Beaver Pipe Tools, Inc., 310 Dana, N. E., Warren, O. 4 p. bulletin on Beaver pipe tools, including new ratchet for range of sizes from ¼ to 1¼ in.

No. 2212—PNEUMATIC PRODUCTS: C. A. Norgren Co., Inc., Denver, Colo. 24 p. catalog of pneumatic products, including air line lubricators, regulating and reducing valves, gas regulators, strainers, blow valves, cocks, air vents, hose couplings, gauges, and other equipment.

No. 2213—POWER TRANSMISSION EQUIPMENT: Boston Gear Works, Inc., 955 W. Washington Blvd., Chicago, Ill. 256 p. pocket size catalog of power transmission equipment, including bearings, chains, couplings, gears, pillow blocks, pulleys, universal joints, speed reducers, and other products.

No. 2214—PUMPS: Roots-Connersville Blower Corp., 16th St. & Columbia Ave., Connersville, Ind. 4 p. bulletin on turbine pumps for industrial services, describing and illustrating features, and giving a selection table.

No. 2215—PUMPS: Worthington Pump & Machinery Corp., Harrison, N. J. 8 p. bulletin on "Mixflo" centrifugal pumps in sizes from 12 to 84 in., capacities 1,000 to 225,000 gpm at heads from 5 to 50 ft. Applications include condenser circulation service, sewage disposal, drainage and irrigation.

No. 2216—REFRIGERATION: Carrier Corp., 850 Frelinghuysen Ave., Newark, N. J. 20 p. booklet entitled "46 Years' Experience," describing this company's compressors, cold diffusers and evaporative condensers, as well as auxiliary equipment, for air conditioned refrigeration.

No. 2217—REFRIGERATION COMPRESSORS: Mills Novelty Co., 4100 W. Fullerton Ave., Chicago, Ill. "Why," a book telling why the publisher is in the refrigeration compressor business, illustrated with striking photographs. Text is brief but informative.

No. 2218—SPEED REDUCERS: Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. 8 p. bulletin on speed reducers, single and double reduction series with single helical gears, antifriction bearings, and splash lubrication.

No. 2219—STOKERS: Chicago Automatic Stoker Co., 14 N. Clinton St., Chicago, Ill. 4 p. bulletin describing this company's improved automatic stoker, describing features of the unit in some detail.

No. 2220—THERMOMETERS AND PRESSURE GAUGES: Brown Instrument Co., Div. of Minneapolis-Honeywell Regulator Co., 4534 Wayne Ave., Philadelphia, Pa. (a) 72 p. catalog of indicating, recording and controlling thermometers and pressure gauges, and hygrometers for controlling humidity and temperature. Complete information is given on the various instruments, the charts are described, and several in-

FOR YOUR CONVENIENCE

Heating, Piping and Air Conditioning,
6 N. Michigan Ave., Chicago, Ill. [12-36]

Please ask the manufacturer to send me more information about the equipment mentioned under the following reference numbers in "Equipment Developments" and "Recent Trade Literature." (Circle the numbers in which you are interested):

1124	1125	1126	1127	1128	1129	1130
1131	1132	1133	1134	1135	1136	1137
1138	1139	1140	1141	1142		
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2201	2202	2203	2204	2205	2206	2207
2208	2209	2210a	2210b	2211	2212	2213
2214	2215	2216	2217	2218	2219	2220a
2220b	2221	2222	2223	2224	2225	2226

Name ..... Title .....

Company .....

Address .....

City ..... State .....

stallations are illustrated. Accessory equipment is included. (b) Broadside entitled "Here's the Answer to Your Temperature Problem," describing thermometer controllers and "Con-Tac-Tor" mercury switches, and the use of this equipment.

No. 2221—TOOLS: Otto Bernz Co., Inc., Rochester, N. Y. 40 p. looseleaf catalog of pipefitters' and plumbers' tools, including torches, fire pots, leak detectors, etc.

No. 2222—UNIONS: Jefferson Union Co., Lexington, Mass. 4 p. circular illustrating various types of unions available in stock.

No. 2223—UNIT HEATERS: National Fan & Blower Corp., 543 W. Washington St., Chicago, Ill. 8 p. bulletin on propeller type and blower type unit heaters, describing their features, showing several types of installations, and giving capacity tables, dimension charts and other data.

No. 2224—VENT VALVES: Maid-O'-Mist, Inc., 180 N. Wacker Dr., Chicago, Ill. Data sheet including description of "No. 7 Auto-Vent" used on hot or cold water lines to vent air, with extensive application where well water is used for summer cooling.

No. 2225—WATER CONDITIONING: D. W. Haering & Co., Inc., 3408 W. Monroe St., Chicago, Ill. 16 p. booklet entitled "Organic Methods of Scale and Corrosion Control," by David W. Haering, giving scientific information on the application of organic chemicals to water conditioning problems. The various chemical theories employed in this field are defined, history of the subject is given, and an explanation of modern control methods is included.

No. 2226—WELDERS: Harnischfeger Corp., 4400 W. National Ave., Milwaukee, Wis. Folder describing features of "Smootharc" welders, which include single control, self-stabilization and self-excitation.

"Devlin" means Dependability

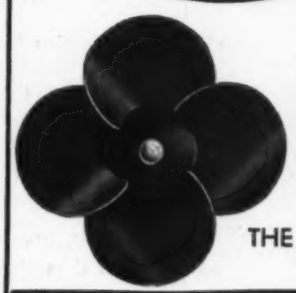
DEVLIN FITTINGS

FRETZ NIPPLES

Thomas Devlin Mfg. Co., Inc.
Burlington, New Jersey

ASK ANY RECOGNIZED JOBBER

TORRINGTON FANS AND BLOWER WHEELS



Patented Alloy Aluminum Blower Wheels. Balanced, Efficient, Rugged, Quiet.

New patented quiet propeller fan blade. The most outstanding development in its field in recent years.

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By the best authorities

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Good, sound, practical information which will help greatly in simplifying your work and which is written by the industry's best authorities. This best describes the contents of every issue of HEATING, PIPING *and* AIR CONDITIONING.

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Randall Pillow Blocks give long, trouble free operation. This is due to the Randall graphite, an exclusive formula, which will not crack or wash out, giving continuous lubrication, and lengthening the life of the bearing. Used by most manufacturers in the air conditioning field. Self-lubricating, self-aligning, quiet. Write for new catalog describing complete line of Randall Pillow Blocks.

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DEPT. 1210—609 W. LAKE ST. CHICAGO, ILL.

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8 cents for each word including heading and address. Count nine words for keyed address. Minimum $2.00 for each insertion. One inch $4.00. Cash must accompany order. Copy must be in our hands by the twenty-fifth of the month previous to issue.

SITUATIONS WANTED

SALES ENGINEER: Sixteen years sales experience in the sale of Heating, Ventilating, Drying and all kinds of Air Handling apparatus. Desires to represent manufacturers of above in New England. Address Key 270-A, HEATING, PIPING AND AIR CONDITIONING, 6 No. Michigan Ave., Chicago.

SITUATION OPEN

DISTRIBUTORS WANTED—Firm now contracting air conditioning and heating contractors. By manufacturer of highest quality copper extended surface heat transfer units. Address Key 271-A, Heating, Piping and Air Conditioning, 6 No. Michigan Ave., Chicago.

AGENTS WANTED

WANTED—Sales Engineers for New England and Eastern Territories for a complete and proven line of Forced Warm Air Heating and Air Conditioning and split steam systems. None but men with experience and proven sales ability need apply. Address Key 268-A "HEATING, PIPING AND AIR CONDITIONING," 6 No. Michigan Ave., Chicago.

MISCELLANEOUS

FOR RECEIVERS STEAM TRAPS REGULATORS ETC.

SEAMLESS COPPER FLOATS

Naugatuck Mfg. Co., Union City, Conn.

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FOR COOLING COILS . . .

only sound, dependable pipe will do . . .

THAT is why NATIONAL Pipe for Ammonia Purposes is first choice among builders and users of modern ventilating and air conditioning systems.

Specially made—and specially tested for just such service—this superior pipe is a permanent safeguard against premature replacement.

Two special manufacturing processes make its dependability doubly sure. In the first, Spellerizing, the bloom is worked and re-worked to eliminate irregularities and make a sound, uniformly dense metal. The second, the Scale Free Process, removes the mill scale from both inside and outside surfaces, eliminating the prime source of pitting and internal corrosion.

As a further check, each length of pipe for this purpose is carefully inspected and tested. Both crop ends of every length are crushed to make certain that the weld is sound, and the finished pipe is tested internally with a hydrostatic pressure far above requirements of standard specifications.

This special pipe also has workability because it is highly ductile — which means easier, more economical fabrication. It is easy to bend and coil — threads well, flanges readily — makes it possible to do a good workman-like job every time. Descriptive booklet is yours for the asking.

NATIONAL TUBE COMPANY

PITTSBURGH, PA.

Columbia Steel Company, San Francisco, *Pacific Coast Distributors* · United States Steel Products Company, New York, *Export Distributors*

UNITED STATES STEEL

AIR CONDITIONING
TRENDS
JANUARY 1937
Issued From "AIR CONDITIONING HEADQUARTERS"
Keeney Publishing Co., Publishers of "Heating, Piping & Air Conditioning" and "American Artisan" • 6 No. Michigan Ave., Chicago
HOW IMPORTANT ARE THE UTILITIES TO YOUR SALES PROGRAM IN 1937
Power Company Executive Says Better Understanding is Vital to Growth of Air Conditioning
Stressing the "mutual interest" of the manufacturer of air conditioning equipment and the public utility industry which sees in air conditioning its most important load potential since the introduction of electric lighting, Robert S. Hitchcock, vice-president of sales for the General Light & Power Company, challenges both industries to work together for mutual profit in 1937.
In a thought provoking interview, Mr. Hitchcock said that neither the manufacturer nor the utility "have begun to
Air Conditioning TRENDS Makes its Bow
Air conditioning has emerged out of infancy and adolescence to the stature of a full grown industry within the span of a young man's business life time.
It is destined to enter upon a stage of commercial expansion second to few industries of our time.
The brilliant engineers who conceived and founded it are passing on the torch of leadership to an equally gifted group of sales-minded merchandisers and executives gifted with the "money sense" in management.
"Trends" is dedicated to those whose interest leans more heavily to the Sales Side of Air Conditioning. Each month it will

A MONTHLY NEWS BULLETIN to interpret the SALES SIDE of the AIR CONDITIONING Industry

● We believe sales, advertising and administrative executives in Air Conditioning can use to good business advantage a regular medium of information to reflect and interpret important sales trends in this fast-growing industry.

The engineering problems of the industry are being competently and adequately handled from a publication viewpoint. Similarly authoritative treatment of its sales and merchandising aspects is needed.

Where can the sales and advertising manager, the board chairman or the president put his finger on facts and trends that will assist him in charting a course through the troublesome and exciting days ahead?

BREWSTER S. BEACH

"Air Conditioning Trends," an informal monthly news bulletin to be issued by Keeney Publishing Company starting in January, has been designed to fill this need. Each issue of "Trends" will be devoted to one or more important and basically fundamental subjects that are of current interest to those responsible for the business development of Air Conditioning. Every month it will attempt to feel the commercial pulse of Air Conditioning and to report it for the benefit of executives who must keep abreast of the most progressive thought.

The editor of "Trends" will be Brewster S. Beach, public relations consultant of New York, formerly advertising manager and director of publicity of Carrier Corporation, who for many years has been prominently identified with industrial promotion.

"Trends" is not a commercial venture. It is a contribution and a service to better selling and promotion of Air Conditioning. It will be distributed each month with the compliments of "Heating, Piping and Air Conditioning" and "American Artisan" to selected sales, advertising and administrative executives within the industry.

"HEATING, PIPING and AIR CONDITIONING"
"AMERICAN ARTISAN"

PUBLISHED BY KEENEY PUBLISHING CO., 6 NO. MICHIGAN AVE., CHICAGO

Complete Line

TO MEET EVERY INDUSTRIAL HEATING REQUIREMENT....

Plain common sense, isn't it—to know all the facts before making an important heating equipment purchase? Then investigate Clarage Unit Heaters, for Clarage Units offer many superiorities which mean dollars saved and better heating results.

Clarage Units are available in two types, with plenty of sizes in each type to insure exactly the right selection.

1—UNITHERM UNIT HEATERS, "big boys" for large area industrial service. Furnished with our remarkable economy feature, Syncrotherm Control. Built for floor, wall or ceiling installation. Equipped with positive centrifugal fans. Rugged heating element good for pressures to 200 pounds. Ball bearings on fan shaft, and ball bearing motor. All parts easily accessible. Direct connected or V-belt drive. Units that do an improved heating job at decidedly lower cost.

2—CLARCO UNIT HEATERS, "little fellows" for small space heating in factories, garages, offices, stores, etc. Heating element good for pressures to 150 pounds. Quiet running fan and motor. Designed for maximum operating economy; built for long service.

Write us, outlining your heating problem.

Save Fuel! Save Piping! Save Traps!

UNITHERM UNIT HEATERS with Syncrotherm Control at No Extra Cost

Decidedly different is our principle of large space, industrial heating. We recommend Clarage Floor-Mounted UNITHERM Unit Heaters equipped with Clarage Syncrotherm Control. It is Syncrotherm Control (patented feature) which enables us to show such substantial savings in fuel cost.

With Syncrotherm Control the unit heater fans operate ALL the time during working hours, giving a continuous NON-STOP circulation of warm air.

To maintain any desired temperature, Syncrotherm Control regulates the amount of air passing THROUGH AND AROUND the heating coil. Marked economies in operating cost are the result. No hot ceilings — no cold floors! Syncrotherm Control makes Clarage UNITHERM Unit Heaters EASY on the coal pile.

Then, too, our floor mounted units utilize a very simple heating layout. There is invariably LESS piping and FEWER traps required — big saving in installation cost.

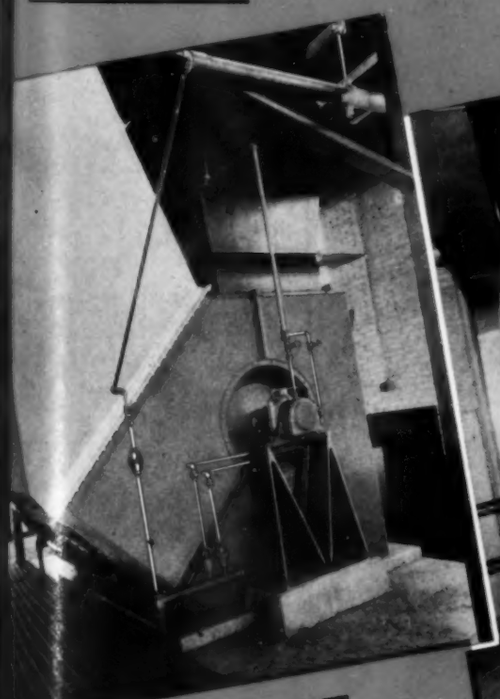
Before you buy, at least be informed on this latest factory heating development. Get a complete explanation of Syncrotherm Control by writing for Clarage FREE Bulletin 103.

SPECIFY CLARAGE for
COMPLETE AIR CONDITIONING · VENTILATION · HEATING · COOLING · MECHANICAL DRAFT · FANS & BLOWERS FOR INDUSTRIAL NEEDS

CLARAGE FAN COMPANY • Kalamazoo, Mich.
SALES ENGINEERING OFFICES IN ALL PRINCIPAL CITIES

CONSULT CLARAGE FIRST

Whether it's heating, cooling or complete air conditioning, mechanical draft or any one of a hundred different fan applications—we can furnish the required equipment. And the name CLARAGE is a definite assurance of efficient, dependable performance. All Clarage Units are scientifically designed and tested in accordance with accepted Test Codes—built of the finest materials—backed by 25 years' experience doing one thing well in one field.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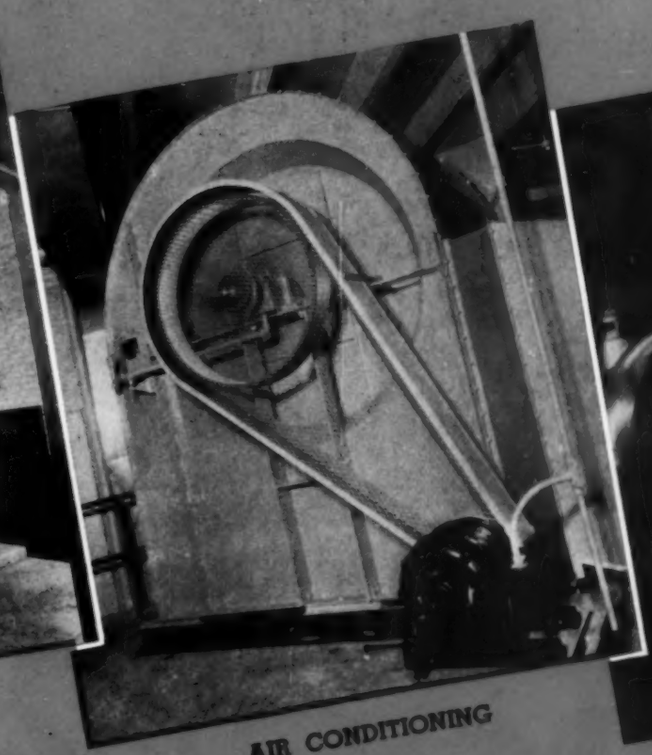
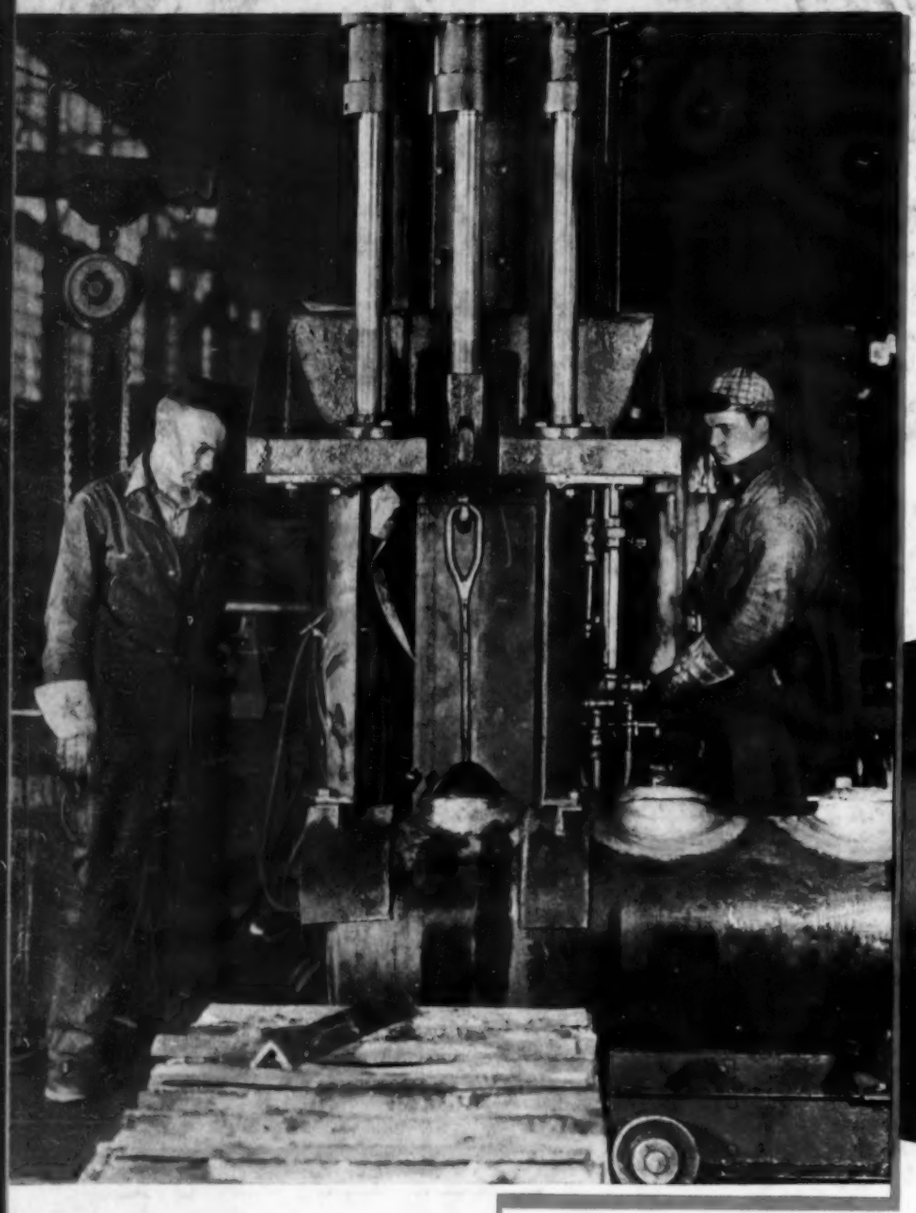

AIR CONDITIONING

FANS AND BLOWERS

THOUSANDS OF DOLLARS INVESTED



To Make Every Weld A Plain Butt We

Seven Reasons For Saying
"Give The Plans To Grinnell"

KNOWLEDGE OF TODAY'S CONDITIONS

INTERPRETATION OF IDEAS AND PLANS

ADVANCED PLANT FACILITIES

THOROUGH TESTING

EASY, RAPID ERECTION

ECONOMY IN COST

ALL WORK QUALIFIED FOR INSURANCE

To give meaning to the phrase, "advanced plant facilities", we illustrate one of Grinnell's powerful extruding machines. These giants represent thousands of dollars invested for just one purpose: to make every outlet in a Grinnell Prefabricated Piping installation a plain circumferential outlet, easily butt-welded by any qualified pipe welder. The smooth contours, accurate positioning of the nozzle, and uniform wall thickness that characterize Grinnell Prefabrication result from the use of these machines.

This is one of the unusual plant facilities that makes the finished job easier with Grinnell Prefabricated Piping. One of the seven reasons (see left) why experienced engineers advise, "Give the plans to Grinnell whenever piping is involved".

GRINNELL COMPANY
INC.
EXECUTIVE OFFICES PROVIDENCE, R. I.
Branch Offices in Principal Cities

GRINNELL

. . . . WHENEVER PIPING IS INVOLVED . . . .